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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

ORGANIZATIONAL, DS, GS, AND DEPOT MAINTENANCE MANUAL

INSTALLATION PRACTICES FOR AIRCRAFT ELECTRIC AND ELECTRONIC WIRING

This copy is a reprint which includes current pages from Changes 2 and 3. Change 1 has been superseded by Change 2.

HEADQUARTERS, DEPARTMENT OF THE ARMY

AUGUST 1968

Technical Manual)
)
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HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C., 14 August 1968

ORGANIZATIONAL, DS, GS, AND DEPOT MAINTENANCE MANUAL

INSTALLATION PRACTICES FOR AIRCRAFT

ELECTRIC AND ELECTRONIC WIRING

TM 55-1500-323-25 is published for the use of all concerned.

By Order of the Secretary of the Army:

W. C. WESTMORELAND,
General, United States Army,
Chief of Staff.

Official:
KENNETH G. WICKHAM,
Major General, United States Army,
The Adjutant General.

DISTRIBUTION:
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SECTION I

INTRODUCTION

1-1. GENERAL.

1-2. This is one of a series of manuals prepared to assist military personnel engaged in the general maintenance and repair of aircraft. The area covered by this manual is that of the aircraft electrical system.

1-3. The satisfactory performance of present-day aircraft depends to a very great extent on the continuing reliability of its electrical system. Improperly or carelessly installed wiring can be a source of both immediate and potential danger, and many malfunctions and failures of the electrical system can be traced to this cause. The performance of the system depends on the quality of the design, plus the workmanship used in making the installation. The continued proper performance of the system depends on the "know-how" of the men who do the inspection, repair and maintenance.

1-4. It is highly important therefore that maintenance and repair operations, as well as the original installation, be made in accordance with the best available techniques in order to eliminate possible failures or at least to minimize them.

1-5. PURPOSE OF MANUAL

1-6. The purposes for which this manual was written are as follows:

a. To gather together under one cover the recommended practices and techniques to be used for installing, repairing and maintaining aircraft electrical wiring.

b. To standardize these techniques and methods so that electrical installations will be done in a uniform manner.

c. To indoctrinate all personnel with the importance of good workmanship.

d. To point up the failures which may result from poor workmanship.

e. To promote safety by pointing out and prohibiting unsafe practices.

1-7. SOURCE OF INFORMATION.

1-8. The information contained in this manual represents the best current knowledge and practice in the aircraft electrical field. It has been compiled with the cooperation and assistance of the country's leading airframe manufacturers, airline operators and military overhaul and repair bases. Many of the illustrations have been provided by the manufacturers of electrical accessories used in aircraft.

1-9. SCOPE

1-10. This manual covers all general purpose wiring and wiring devices in aircraft used for the interconnection of equipment. It also includes thermocouple systems and coaxial cabling.

1-11. The manual is not concerned in any way with design problems, or with the selection of wire, cable, connections, etc. However, in some cases, materials are noted as meeting specific temperature or environmental requirements.

1-12. INTENDED USE.

1-13. This manual is intended primarily for the use of personnel engaged in maintenance and repair under government contract or at military bases. Its use is mandatory for such personnel, except where any procedure contained in it conflicts with any government specification or document, in which case the government specification or document shall take precedence and a report describing the conflict shall be submitted. The manual will also be available to contractors as a guide and as recommended practice, but its use is not mandatory to these contractors. However, the practices used by the contractor will always be compatible with those of this publication so that modern techniques may be used to maintain the aircraft regardless of the manufacturer.

1-14. The procedures described in this manual are compatible with those currently used by airframe manufacturers. Repair and maintenance accomplished in accordance with this book should result in a quality equivalent to that in the original installation.

1-15. For specific installations, this manual is intended to be used in conjunction with applicable Handbook of Maintenance Instructions. Copies of Government Specifications and other official documents referenced herein may be obtained upon application to the Commanding Officer, Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pa. 19120. Copies of the Department of Defense Index of Specifications and Standards may be obtained by directing requests as follows:

For Department of the Navy, to the Commanding Officer, U. S. Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pa. 19120

For Department of the Air Force, to the Commander, Wright-Patterson Air Force Base, USAF Engineering Specification and Drawing Branch, Administrative Services Office, Attn: EWB, Wright-Patterson Air Force Base, Ohio

For other than official use, from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

1-16. ARRANGEMENT OF MATERIAL.

1-17. The material comprising the manual is divided into sections. Each section describes and illustrates the recommended procedure for a single operation, or for a series of related operations.

1-18. The first six sections contain procedures for preparing and identifying wire, and for assembling it to connectors, terminals, splices and taper pins. Later sections deal with procedures for thermocouple wiring, bonding and grounding, soldering, potting, routing and support of wire bundles, and preparation and installation of conduit, buses, terminal blocks, junction boxes, lamps and protective devices. Directions for emergency repairs are found in the final section.

1-19. The material in each section is arranged as far as possible in the general order in which the operations are performed. Illustrations and tables are located as near as possible to the related text. Each section is headed by an introduction containing a short description of the subject and its function in the aircraft electrical system. Where necessary for clarity, a list of definitions is included.

1-20. Also included in the introduction of each section is a listing of applicable government specifications for the various materials required, and design procedures on which these installation techniques are based.

1-21. REVISIONS.

1-22. Revisions and additions will be made from time to time to insure that the material in the manual will always reflect the best current techniques and keep abreast of the new developments in the field. Suggestions for correcting and improving this manual are invited and should be sent to:

By Naval activities.
Chief, Bureau of Naval Weapons,
Department of the Navy,
Washington D.C. 20360

By Air Force activities:
Headquarters, San Antonio Air Material Area,
U.S. Air Force,
Kelly Air Force Base,
San Antonio, Texas

By U. S. Army Activities:
Commanding General,
U. S. Army Aviation Systems Command,
P. O. Box 209,
St. Louis, Missouri 63166.

SECTION II

WIRE AND CABLE PREPARATION

2–1. INTRODUCTION.

2–2. GENERAL. In order to make installation, maintenance and repair easier, runs of electric wire and cable in aircraft are broken at specified locations by junctions such as connectors, terminal blocks, buses, etc. Before assembly to these junctions, wires and cables must be cut to length, identified, stripped and if required, tinned.

2–3. SCOPE. This section describes and illustrates the recommended procedures for preparing wire and cable for attachment to junctions, and for terminating shielded cable.

2–4. DEFINITIONS.

a. Insulated Wire. For purposes of electric and electronic installation in aircraft, an insulated wire consists of a metal conductor covered with a dielectric or insulating material, (see figure 2–1). Insulated wire is usually referred to as "wire" and will be so designated in this manual. Wires used in aircraft contain stranded conductors for flexibility. Insulations may consist of several materials and layers to provide dielectric insulation, thermal protection, abrasion resistance, moisture resistance and fluid resistance. Wires commonly used in aircraft are described in table 2–1.

b. Cable. See figure 2–2. The term cable, as used in aircraft electrical installations includes the following:

1. Two or more insulated conductors, contained in a common covering, or twisted together without a common covering (multi-conductor cable).

2. A single insulated conductor, or two or more insulated conductors with an overall shield, or with an overall shield and a jacket over the shield (shielded cable).

3. Two conductors twisted together (twisted pair).

4. A single insulated center conductor with a metallic braided outer conductor (coaxial cable). The concentricity of center and outer conductor is carefully controlled during manufacture to insure that they are coaxial.

Cables commonly used in aircraft are:

MS25192, Spec. MIL-C-7078	Single or multiple conductor, using MS25190 wire, shielded with tinned copper braid.
MS25313, Spec. MIL-C-7078	Similar to MS25192, but covered with a nylon jacket.
Spec. MIL-C-27500.	Single or multiple conductor, using any wire in Table 2-1, shielded with tinned, silver-coated, or nickel-coated copper braid as appropriate and covered with appropriate jacket.
Spec. MIL-C-5756.	Single or multiple conductor, rubber insulated conductor, rubber jacket.
Spec. MIL-C-17.	Coaxial cable.

NOTE

Instructions for coaxial cable are in section IV.

c. Soft Solder. For use in aircraft electrical installations, soft solder is a mixture of 60% tin and 40% lead, as described in Federal Specification QQ-S-571. It may be in bar form to be melted for tinning, or in the form of rosin core wire solder for use with soldering iron.

d. Flux. For use with soft solder, flux is water-white rosin, dissolved to paste-like consistency in denatured alcohol.

2–5. REFERENCE SPECIFICATIONS AND DRAWINGS

QQ-T-25	Tape, Electrical Wire, Flexible Insulating Sleeving, Marking Machine, (Foil, Wire Identification Marking)
QQ-S-571	Solder: Lead Alloy, Tin Lead Alloy, and Tin Alloy
MIL-I-631	Insulation, Electrical, Synthetic Resin Composition, Non-rigid
MIL-T-713	Twine and Tape, Lacing and Tying, for use in Electrical and Electronic Equipment
MIL-C-1140	Glass Fiber; Yarn, Cordage, Sleeving, Cloth and Tape
MIL-I-3158	Insulation Tape, Electrical Glass-Fiber (Resin Filled); and Cord, Fibrous Glass
MIL-I-3190	Insulation, Electrical, Sleeving, Flexible, Treated

MIL-M-4528	Marking Machine, Wire and Plastic Tubing, Identification
MIL-W-5086	Wire, Electrical, Insulated Aircraft
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-A-6091	Alcohol; Ethyl, Specially Denatured, Aircraft
MIL-S-6872	Soldering Process, General Specification for
MIL-W-7072	Wire, Electrical, 600 volts, Aluminum
MIL-C-7078	Cable, Power, Electrical, 600 volts, Shielded
MIL-W-7139	Wire, Electrical, Copper Insulated, 600 volts, 400 Degrees F
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
MIL-W-8777	Wire, Electrical, Copper, 600 volts, 150 degrees Centigrade
MIL-W-16878	Wire, Electrical, Insulated, High Temperature
MIL-F-21608	Ferrule, Shield Grounding, Insulated, Crimp Style
MIL-W-22759	Wire, Electric, Fluorocarbon Insulated, Copper
MIL-I-23053	Insulation Sleeving, Electrical, Flexible, Heat Shrinkable
MIL-C-25038	Cable, Electrical, Aircraft, High Temperature and Fire Resistant
MIL-W-27300	Wire, Electrical, Polytetrafluoroethylene Insulated, Copper, 600 volt
MS25311	Ferrule, Shield Grounding, One Piece, Insulated
MS25312	Tool, Crimping, Hand, for Insulated Shield-Grounding Ferrule
MS25316	Gauges, for MS25312 Crimping Tool

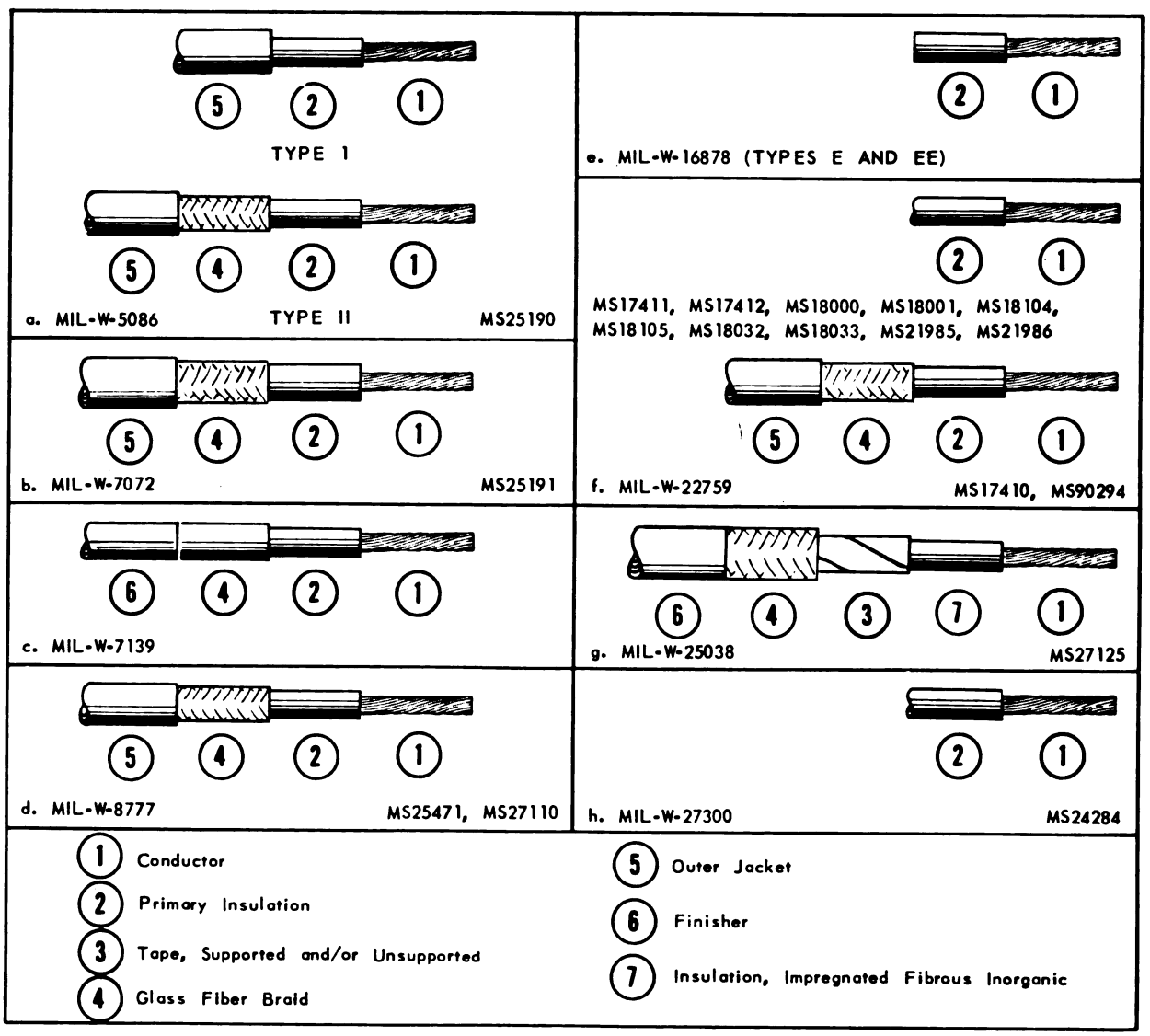


Figure 2–1. Wires Commonly Used in Aircraft

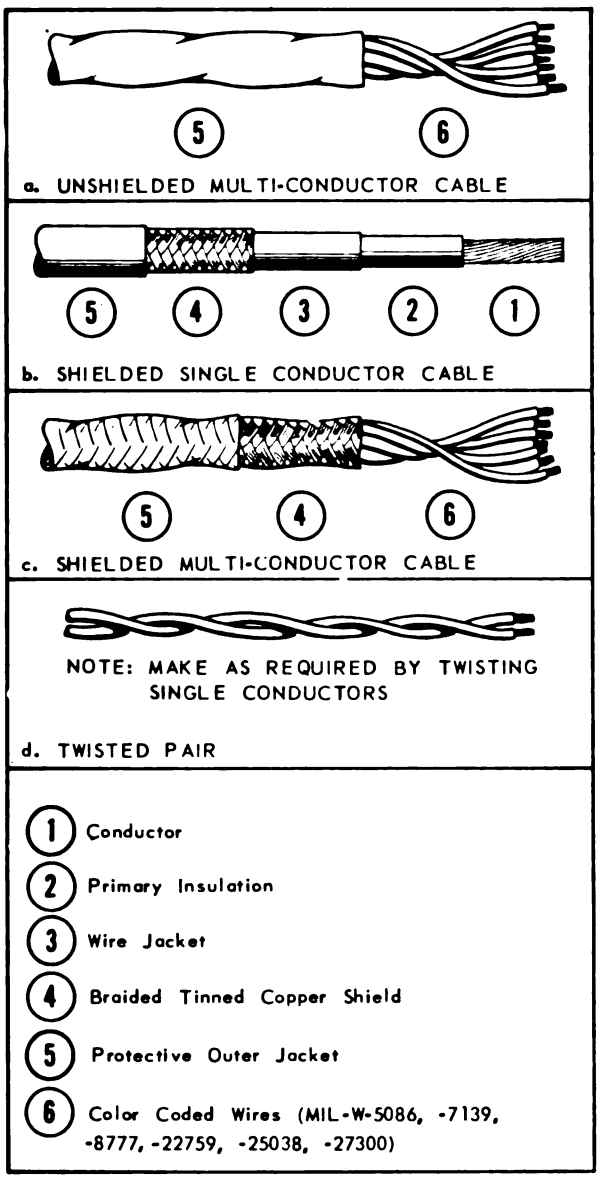


Figure 2–2. Cables Commonly Used in Aircraft

2–6. CUTTING WIRE AND CABLE

2–7. GENERAL. Cut all wires and cables to lengths given on drawings or wiring diagrams. Cut wire and cable so that cut is clean and square and wire is not deformed. See figure 2–3. After cutting reshape large diameter wire with pliers, if necessary.

CAUTION

Make sure that blades of cutting tools are sharp and free from nicks. A dull blade will deform and extrude wire ends.

2–8. CUTTING COPPER WIRE AND CABLE. To cut a large number of heavy wires or cables, use a circular saw with a cable cutting blade. A cable cutting blade is similar to a meat slicing blade (no teeth). See figure 2–4a.

WARNING

Do not use a circular saw without an adequate guard over the blade.

Heavy or light copper wires can also be cut with bench shears such as shown in figure 2–4b.

2–9. To cut a few heavy gage copper wires or cables use a fine tooth hack saw. A fine tooth hack saw has 20 or more teeth per inch. See figure 2–4c for use of hack saw and saw vise which protects heavy wire during cutting.

2–10. To cut a few light gage copper wires, use diagonal pliers. Do not attempt to cut wires larger than AN-8 with diagonal pliers.

2–11. CUTTING ALUMINUM WIRE. Be careful when cutting aluminum wire to avoid deforming the conductors. Aluminum is more brittle than copper, and if deformed, aluminum wire should be reshaped carefully.

CAUTION

Never cut aluminum wire with tools which have reciprocating motion, such as a hack saw. Reciprocating cutting action "work hardens" aluminum. This will lead to broken and torn strands.

2–12. To cut a large number of aluminum wires use a power circular saw with cable cutting blade as shown in figure 2–4a. Do not use toothed blade for cutting aluminum wire.

CAUTION

If cutting tool has been used for other metals, wipe blades clean before cutting aluminum. Copper or steel chips will cause aluminum to corrode.

Special cable shears with concave cutting edges such as pruning or dehorning shears may also be safely used to cut aluminum wire. A cable shear of this type is illustrated in figure 2–4d.

TABLE 2-1

Wire used in Aircraft Electrical Installations

Standard	Spec.	Conductor	Insulation	Voltage Rates	Temp. Rating Conductor	Remarks
MS25190 Type I	MIL-W-5086	tinned copper	PVC, nylon	600V	105°C	Interconnection, low temperature, general purpose
Type II	MIL-W-5086	tinned copper	PVC, glass braid, nylon	600V	105°C	Same as Type I except glass braid gives thermal overload protection but less moisture resistance.
Type III	MIL-W-5086	tinned copper	PVC, glass braid, PVC, nylon	600V	105°C	Same as Type II. Not as common as Types I and II.
Type IV	MIL-W-5086	tinned copper	PVC, nylon	3000V	105°C	Similar to Type I but with higher voltage rating.
MS25191	MIL-W-7072	aluminum	PVC, glass braid, nylon braid	600V	105°C	Aluminum conductor for light weight in larger sizes.
MS25471	MIL-W-8777	silver-coated copper	Silicone rubber, glass braid, polyester braid	600V	200°C	High temperature interconnection. Self-extinguishing of flame in horizontal runs.
MS27110	MIL-W-8777	silver-coated copper	Silicone rubber, glass braid, FEP fluorocarbon	600V	200°C	Same as MS25471, but has smooth surface.
None	MIL-W-7139	silver-coated copper	TFE fluorocarbon and glass	600V	200°C	High temperature interconnecting, self-extinguishing.
None	MIL-W-7139	nickel-coated copper	TFE fluorocarbon and glass	600V	200°C	
MS17331	MIL-W-22759	silver-coated copper	TFE asbestos reinforced	600V	200°C	Abrasion resistant, resist thermal overload.
MS17332	MIL-W-22759	nickel-coated copper	TFE asbestos reinforced	600V	260°C	

TABLE 2-1

Wire used in Aircraft Electrical Installations (cont.)

Standard	Spec.	Conductor	Insulation	Voltage Rates	Temp. Rating Conductor	Remarks
MS17410	MIL-W-22759	silver-coated copper	TFE, glass, FEP	600V	200°C	Similar to MIL-W-7139, but with smooth surface.
MS17411	MIL-W-22759	silver-coated copper	Mineral reinforced TFE	1000V	200°C	Abrasion resistant, smooth surface, can be used to replace MIL-W-7139.
MS17412	MIL-W-22759	nickel-coated copper	Mineral reinforced TFE	1000V	260°C	
MS18000	MIL-W-22759	silver-coated copper	Mineral reinforced TFE	600V	200°C	Similar to MS17411 and MS17412 but thinner wall and less abrasion resistant.
MS18001	MIL-W-22759	nickel-coated copper	Mineral reinforced TFE	600V	260°C	
MS18032	MIL-W-22759	silver-coated copper	Fused laminated TFE	600V	200°C	Hook-up similar to MS21985 and MS21986 but thinner wall and less abrasion resistant.
MS18033	MIL-W-22759	nickel-coated copper	Fused laminated TFE	600V	260°C	Laminated wall is uniform in cross section.
MS18104	MIL-W-22759	silver-coated copper	Extruded TFE polyimide-coated	600V	200°C	Similar to MS18113 and MS18114 but thinner wall and higher abrasion resistance.
MS18105	MIL-W-22759	nickel-coated copper	Extruded TFE polyimide-coated	600V	260°C	
MS18113	MIL-W-22759	silver-coated copper	Extruded TFE	1000V	200°C	Similar to MS21985 and MS21986 but higher voltage rating. Preferred to MIL-W-16878, Type EE
MS18114	MIL-W-22759	nickel-coated copper	Extruded TFE	1000V	260°C	

TABLE 2-1

Wire used in Aircraft Electrical Installations (cont.)

Standard	Spec.	Conductor	Insulation	Voltage Rates	Temp. Rating Conductor	Remarks
MS21985	MIL-W-22759	silver-coated copper	Extruded TFE	600V	200°C	Hook-up. Preferred to MIL-W-16878, Type E
MS21986	MIL-W-22759	nickel-coated copper	Extruded TFE	600V	260°C	
MS27125	MIL-W-25038	nickel-clad copper (27% nickel)	Asbestos, glass, TFE	600V	260°C	Fire resistant wire.
None	MIL-W-16878 Type E	silver - or nickel - coated copper	Extruded TFE	600V	200°C or 260°C	Hook-up, See MS21985 and MS21986.
None	MIL-W-16878 Type EE	silver - or nickel - coated copper	Extruded TFE	1000V	200°C or 260°C	Hook-up, See MS18113 and MS18114.
MS24284	MIL-W-27300	nickel-coated copper	Extruded TFE	600V	260°C	Hook-up. Replaced by MS21986.

NOTES:

Conductor.

Stranded conductor wire is used for flexibility in installation and service. Wire sizes approximate AWG gages, but vary sufficiently so that it is improper to refer to aircraft wire as "AWG". In low temperature wire, strands are tinned to facilitate soldering. In wire rated at 200°C conductor temperature, silver is used to coat strands to protect copper from oxidation and to facilitate soldering. Wires for high temperatures use nickel-coating to prevent oxidation. Nickel-coated wire is more difficult to solder than silver-coated wire, but makes satisfactory solder connections with proper techniques. Nickel-coated wire has less tendency to wick solder and become brittle than silver-coated wire.

Insulation.

Primary Insulation

PVC (Polyvinyl Chloride) - PVC is a common wire insulation. It has good insulation properties and is self-extinguishing after flame.

Silicone Rubber - Silicone rubber is rated at 200°C. It is highly flexible. It is self-extinguishing after flame except in vertical runs. The ash is nonconducting.

TFE-Fluorocarbon (polytetrafluoroethylene) - TFE is widely used as a high-temperature insulation. It will not burn but vaporizes in flame. It will not melt at soldering temperatures. TFE is resistant to most fluids.

FEP-Fluorocarbon (Fluorinated ethylene propylene) - FEP is rated at 200°C, but will melt at higher temperatures. FEP has properties similar to TFE, but is melt-extrudable. It will melt at soldering temperatures.

TABLE 2-1

Wire used in Aircraft Electrical Installations (cont.)

NOTES: (cont.)

Thermal and Abrasion Resistant Materials Used in Intermediate and Outside Layers.

Glass Braid. Widely used to provide thermal resistance and cut-through resistance. However, it may absorb moisture and its use is becoming less prevalent.

Asbestos. Asbestos and other mineral fibers are used to provide high temperatures and flame resistance. Moisture absorpotion is high, but silicone rubber, TFE, or other saturants are used.

Nylon. Widely used in low temperature wires for abrasion resistance and fluid resistance.

Polyimide. A new material with excellent thermal, abrasion, and cut-through resistance characteristics.

Jackets. Extruded nylon, nylon braid, polyester braid, FEP-fluorocarbon, and TFE-impregnated glass braids are used as jackets for fluid and abrasion resistance. Smooth extruded jackets are preferred on wires to be used with grommet-seal connectors.

Hook-up Wire. Hook-up wire is normally used for wire in chassis and other enclosed areas. This wire may be used for interconnection wiring in compact wire harnesses when protected by molded or braided coverings. The term "hook-up" is sometimes used to include interconnecting wire, and the term "chassis wire" is then used to distinguish non-abrasion resistant insulated wire from interconnecting wires.

Interconnecting Wire. Interconnecting wire is designed to withstand all normal aircraft environment (including limited scuffing) without sleeving, jacketing or other protection. However, no wire insulation will withstand continuous scuffing or abrasion and must be installed to minimize such abuse. Medium-abrasion-resistant wire such as MS18000 and MS18001 must be installed with extra care.

Fire Resistance. MIL-W-25038 wire is used in circuits such as fire detection and fire extinguishing circuits where insulation properties during flame are required. This wire may also be used in areas where intermittant temperatures above 260°C are encountered. It will withstand 400°C (750°F) for periods totalling up to 100 hours, during which time it will gradually lose moisture resistance. Its continuous duty rating (10,000 hours) is 260°C.

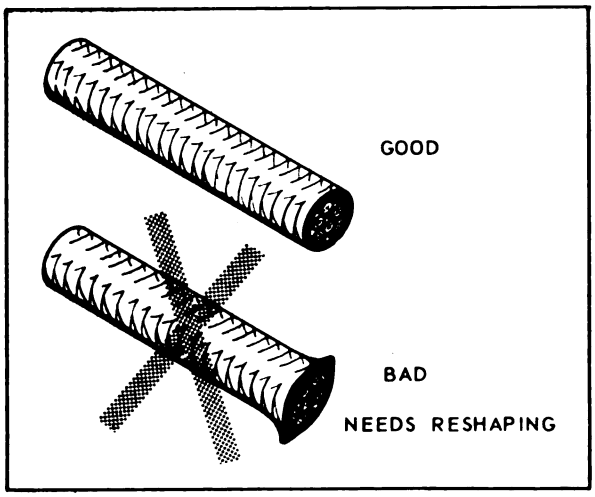


Figure 2–3. Wires After Cutting

2–13. IDENTIFYING WIRE AND CABLE.

2–14. GENERAL. To make maintenance easier, each interconnecting wire and cable installed in aircraft is marked with a combination of letters and numbers which identify the wire, the circuit it belongs to, its gage size and other information necessary to relate the wire to a wiring diagram. This marking is called the cable identification code. Details of the code are given in Military Specification MIL-W-5088. Some general information is given in 2–15 thru 2–17. Wire as received from the manufacturer is printed in a light green color at intervals of one to five feet with the manufacturer's code designation: the MS number and dash number of the wire, and a one, two or three-digit number indicating the color of the basic wire insulation and the color of the stripes (if present). The color code is as follows:

Black 0
Brown 1
Red 2
Orange 3
Yellow 4
Green 5
Blue 6
Violet 7
Gray 8
White 9 (includes also uncolored insulations)

For example, a wire printed with number MS25190A20-913 would designate a wire constructed in accordance with Military Standard drawing MS25190, Type I, size 20, having white insulation (9), a first stripe of brown (1) and a second stripe of orange (3).

Note

When marking wire with the identification code described in 2–15 through 2–17 it is permissible to overstamped the manufacturer's printing.

2–15. WIRE IDENTIFICATION CODE-BASIC. See figure 2–5a. The basic wire identification code used for all circuits except those having the circuit function letters, R, S, T or Y is as follows, reading from left to right:

a. Unit Number - Prefixed where necessary to distinguish between wires in a circuit having identical items of equipment and identification numbers.

b. Circuit Function Letter. Used to identify the function of the particular circuit. See Military Specification MIL-W-5088 for details.

c. Wire number. Used to distinguish between wires with the same circuit function letters.

d. Wire segment letter. Used to distinguish between conductor segments in a particular circuit.

e. Wire size number. Used to designate AN or AL gage size of the wire. Wire size is omitted on coaxial cable. Wire size number is replaced with a dash for thermocouple wire.

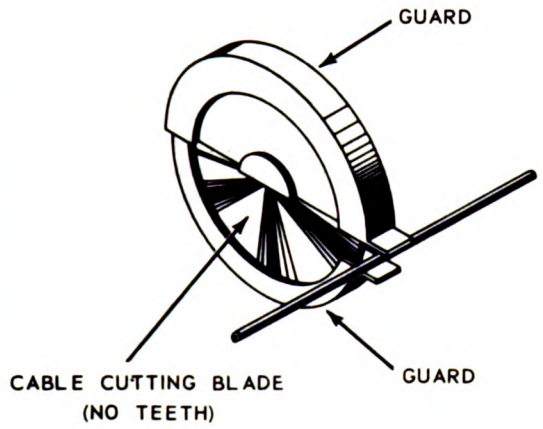
f. Ground, phase or themocouple letter. Used to denote a wire to ground, phase of a wire in a three-phase system, or materials of a thermocouple pair.

2–16. WIRE IDENTIFICATION CODE (R, S and T CIRCUITS). See figure 2–5b. The identification code for circuits R, S and T, (Radio, Radar & Special Electronic circuits), in addition to the basic numbers and letters listed in 2–15, includes another letter after the circuit function letter, called the circuit designation letter, which further identifies the circuit inside the system. See Military Specification MIL-W-5088 for details.

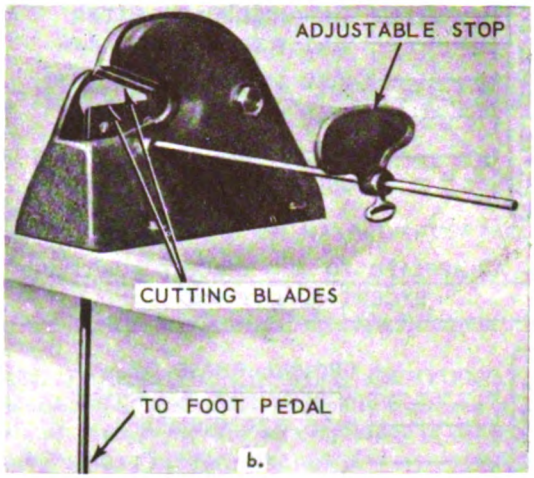
2–17. WIRE IDENTIFICATION CODE (Y CIRCUIT). See figure 2–5c. When the circuit function letter is Y, (indicating a special armament system), the basic code with the addition of a circuit designation letter is used, plus the number of the particular armament system, inserted after the circuit function letter. See Military Specification MIL-W-5088 for details.

2–18. IDENTIFICATION METHODS. The identification code may be stamped on wires either horizontally, as shown in figure 2–5a, b, & c, or if desirable in a particular application, vertically as shown in figure 2-5d. The preferred method of identification is to stamp the identification marking directly on the wire or cable with a hot foil stamping machine. Use this method wherever possible. If the wire insulation or outer covering will not stamp easily, lengths of insulating tubing (sleeves) are stamped with the identification marking and installed on the wire or cable. The following types of wire are usually identified by means of sleeves:

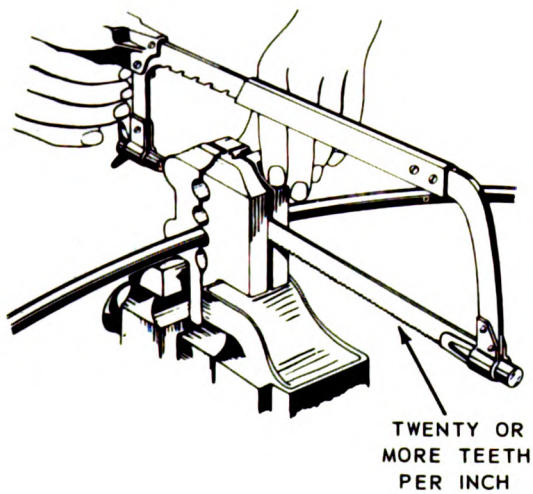
a. Unjacketed shielded wire
b. Thermocouple wires
c. Multiconductor cable
d. High temperature wire with insulation difficult to mark, (such as asbestos, TFE, fiberglass, etc).



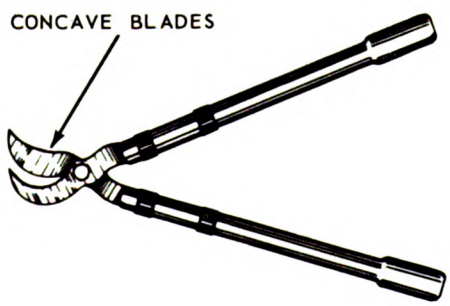
a. CIRCULAR SAW FOR CUTTING WIRE AND CABLE



b. BENCH CABLE SHEAR



c. HACK SAW WITH SAW VISE



d. CABLE SHEARS – PRUNING TYPE

e. DIAGONAL CUTTING PLIERS

Figure 2–4. Wire Cutting Tools

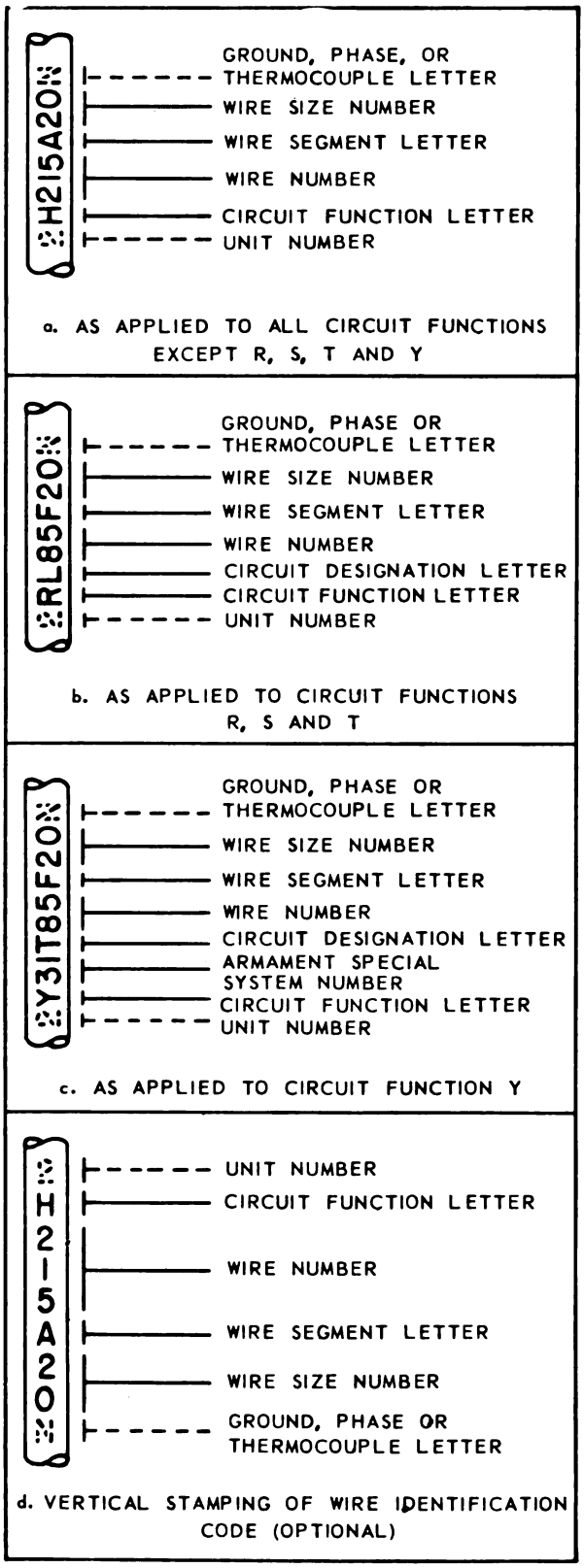


Figure 2–5. Examples of Wire Identification Conding

CAUTION

Do not use metallic markers or bands for identification. Do not use any method of marking that will damage or deform the wire or cable.

Use sleeves only if wire cannot be marked directly. With care some wires, previously thought to be unsuitable for direct marking, can be stamped with a standard marking machine using special foils.

2–19. MARKING OBJECTIVES. Whatever method of marking is used, be sure marking is legible, and that color of stamping contrasts with the wire insulation or sleeve. Use black stamping for light colored backgrounds. Use white on dark colored backgrounds. Make sure that markings are dry so they do not smear.

2–20. SPACING OF STAMPED MARKS. See figure 2–6. Stamp wires and cables at intervals of not more than 15 inches along their entire lengths. In addition stamp wires within three inches of each junction (except permanent splices), and at each terminating point. Stamp wires which are three to seven inches long in the center. Wires less than three inches long need not be stamped.

2–21. LOCATION OF SLEEVE MARKING. See figure 2–7. When wire or cable cannot be stamped directly, install a plastic sleeve marked with the identification number over the outer covering at each terminating end. For Air Force planes, also install marked sleeves at not more than six foot intervals on the entire length of such wire or cable.

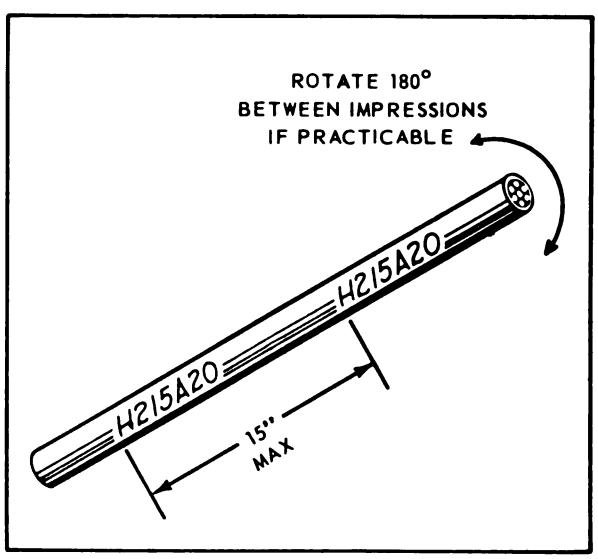


Figure 2–6. Spacing of Identification Stamping on Wire & Cable

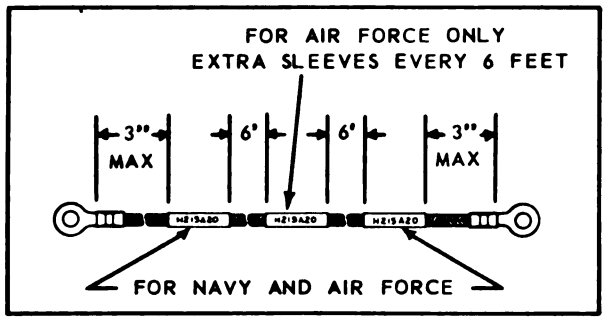


Figure 2–7. Location of Identification Sleeve

CAUTION

Do not use sleeves to change identification of wire or cable which has already been marked, except in the case of spare wires in potted connectors.

2–22. MULTICONDUCTOR CABLE IDENTIFICATION. See figure 2–8. Identify multiconductor cables with marked sleeves installed as described in 2–21. Stamp sleeves with identification marking of each wire in the cable. Immediately following the identification code, stamp letters indicating the conductor color, using the following abbreviations:

BLK-Black	ORN-Orange
BLU-Blue	PR -Purple
BRN-Brown	RED-Red
GY -Gray	WHT-White
GRN-Green	YEL-Yellow

At each terminating end, strip back outer covering as far as necessary and stamp color code letters on insulation of each conductor.

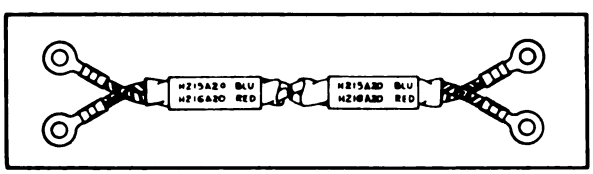


Figure 2–8. Multi-Conductor Cable Identification

2–23. COAXIAL CABLE IDENTIFICATION. See figure 2–9. Identify coaxial cable by direct stamping on the cable or with sleeves. If sleeves are required, install them as indicated in 2–21. In addition, mark coaxial cable on the end terminating in a piece of equipment to match marking on equipment terminal.

CAUTION

When marking coaxial cable take care not to flatten the cable, as this may change the electrical characteristics of the cable.

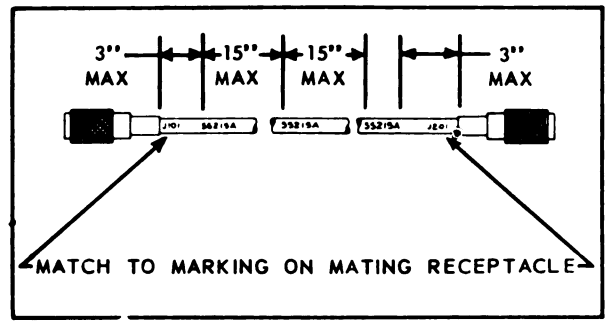


Figure 2–9. Coaxial Cable Identification

2–24. THERMOCOUPLE WIRE IDENTIFICATION. Thermocouple wire which is usually duplexed (two insulated conductors laid side by side) is difficult to mark legibly. Sleeves are installed as described in 2–21. The wire size of the identification code is replaced by the full name of the material of the thermocouple conductor. Thermocouple conductor materials are Alumel - Chromel - Iron - Constantan - Copper.

2–25. IDENTIFICATION AT TERMINAL BOARDS AND ENCLOSURES. See figure 2–10. If possible, mark wires attached to terminal boards and equipment terminals between termination and point where wire is brought into wire bundle. Identify wires terminating in an enclosure inside enclosure if space permits.

2–26. SELECTION OF IDENTIFICATION SLEEVING. For general purpose wiring use flexible vinyl sleeving, either clear or white opaque. For high temperature applications (over 100 degrees C) use silicone rubber or silicone fiberglass sleeving. Where resistance to synthetic hydraulic fluids or other solvents is necessary, use nylon sleeving, either clear or white opaque. Select size of sleeving from table 2–2. Heat-shrinkable polyethlene tubing may also be used to identify wire which cannot be marked directly. Available sizes are given in section XI, table 11–11.

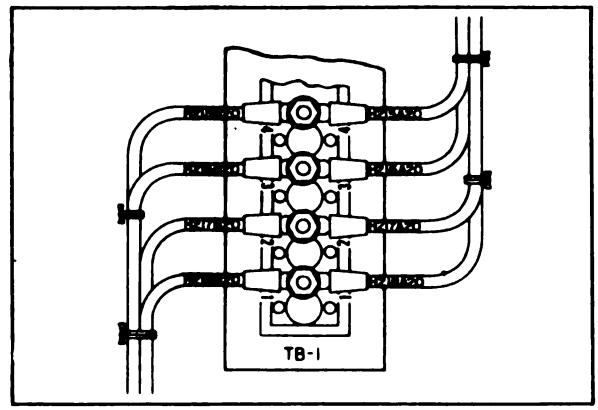


Figure 2–10. Wire Identification at Terminal Board

TABLE 2–2

Sizes of Identification Sleeving

Wire Size			Sleeving Size	
MIL-W-5086 Types I and II AN	MIL-W-5086 Type III AN	MIL-W-7072 AL	No.	Nominal I D (Inches)
#22			11	.095
#20	#22		10	.106
#18	#20		9	.118
#16	#18		8	.133
#14	#16		7	.148
#12	#14		6	.166
#10	#12		4	.208
#8	#10		2	.263
#6	#8	#8	0	.330
#4	#6	#6	3/8	.375
#2	#4	#4	1/2	.500
#1	#2	#2	1/2	.500
#0	#1	#1	5/8	.625
#00	#0	#0	5/8	.625
#000	#00	#00	3/4	.750
#0000	#000	#000	3/4	.750
	#0000	#0000	7/8	.875

2–27. IDENTIFICATION MARKING MACHINES. See figures 2–11 and 2–12 for typical marking machines. For stamping a large number of long wires use an automatic-wire marking machine. In machines of this type (figure 2–11) wire sizes No. 26 through No. 14 are fed through and stamped automatically. Wires larger than No. 14 are fed through by hand, but stamped automatically. For short wires, on repair or maintenance work, a hand-operated wire marking machine is more convenient and economical (figure 2–12). In this type of machine wire is fed through the desired amount by hand, and stamped by operating the handle for each marking. Wire guide holders in sizes to fit wires, and slot holders to hold appropriate size type are furnished to fit the machines. Type is supplied in three sizes, to mark wire No. 26 through No. 00 as shown in table 2–3. Marking foil is available in black or white, (and other colors if needed for special applications).

Note

Store foils at approximately 70°F and 60% relative humidity.

TABLE 2–3

Recommended Sizes of Marking Type

Wire Size	Height of Letters (inches)
#26 & #22	1/16
#20 thru #14	5/64
#12 thru #0000 & Coaxial Cable	7/64

2–28. SET-UP OF MARKING MACHINES FOR WIRE STAMPING. After selecting the proper machine for the job, set it up for the marking procedure as follows: (Refer to figures 2–11 and 2–12).

a. Select from table 2–3 type of correct size for wire to be marked. Make up required identification code and insert into type holder, centering type in holder. Use spacers to prevent crowding letters and numbers.

b. Select marking foil of correct width for length of marking. Use black foil for light colored insulation, and white foil for dark insulation.

c. Select wire guide holder with wire hole to fit wire, and having a slot of same length as slot in type holder.

CAUTION

Use smallest guide into which wire will fit. If guide is too large, wire will not be held firmly, and will be off-centered.

d. Install wire guide and roll of marking foil on machine. Slide type holder into slot provided for it.

2–29. PROCEDURE FOR WIRE STAMPING BY MACHINE. The procedure for stamping wire by machine is as follows:

Note

Good marking is obtained only by the proper combination of temperature and pressure, and is arrived at by trial.

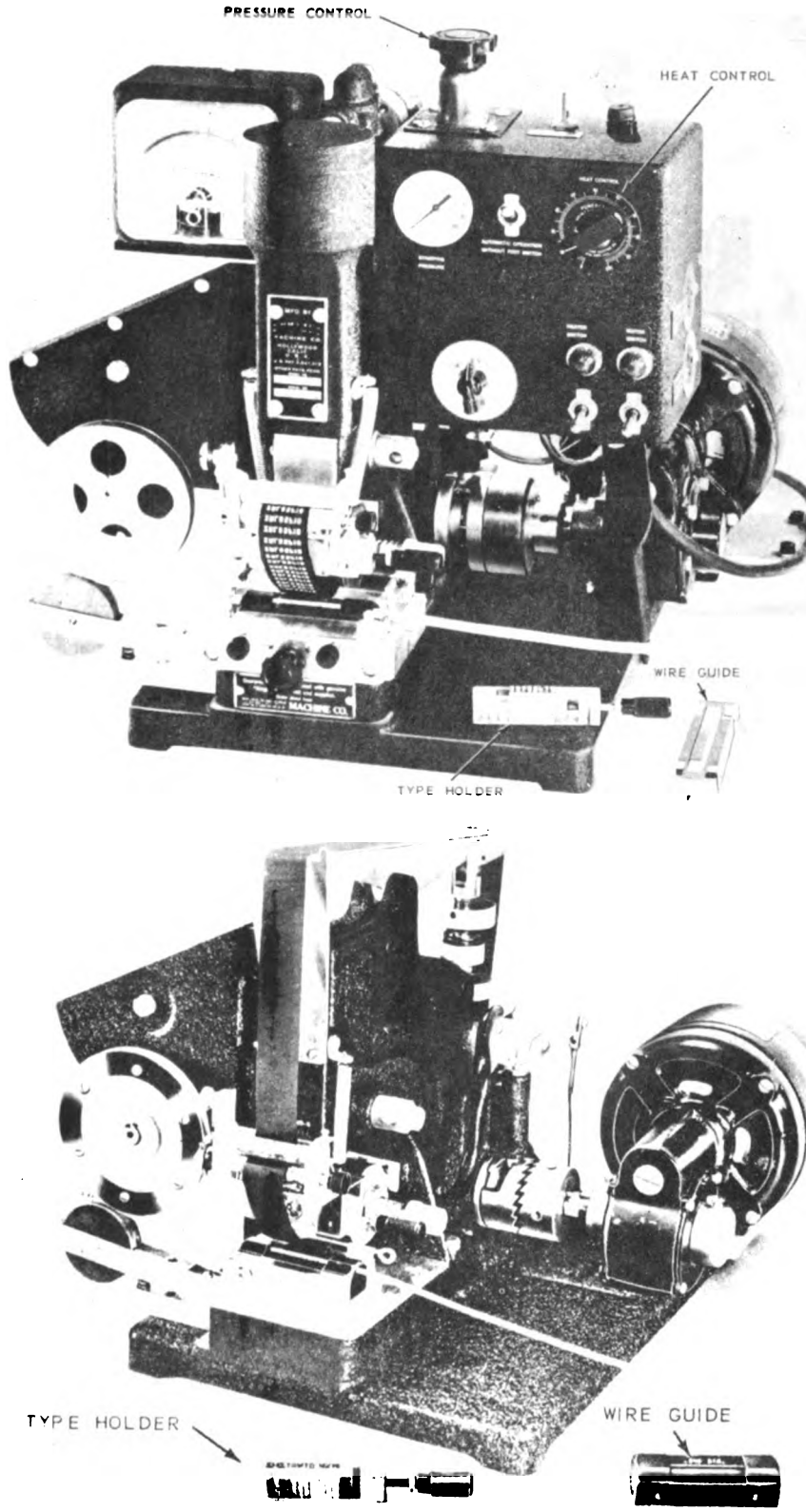


Figure 2–11. Wire Marking Machines – Automatic

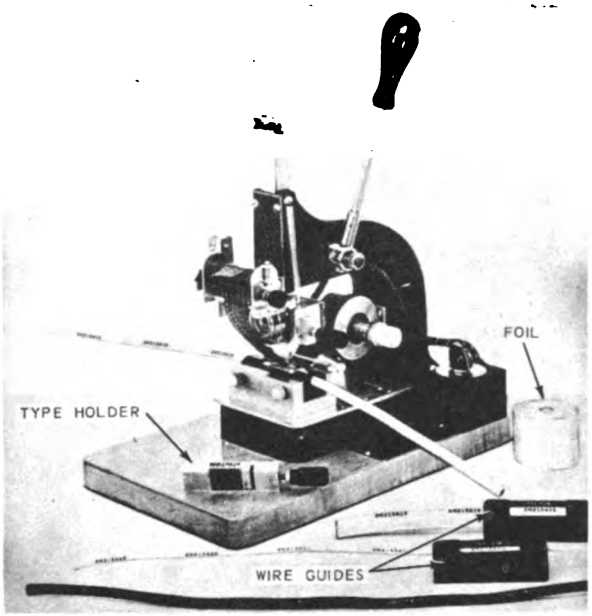


Figure 2–12. Marking Machines – Hand

CAUTION

Avoid excessive heat or pressure, as it may damage the wire insulation.

a. Turn heat to high, then regulate downward to required temperature. See table 2–4 for recommended temperatures.

TABLE 2–4

Recommended Marking Temperatures

Insulation Material	Recommended Temperature
Kel-F	300 to 325°F
Vinyl	400 to 425°F
*TFE	425°F
Nylon	400 to 450°F
**Silicone	400 to 450°F
Polyester	500°F
*FEP	550 to 600°F

*Using special foil

**Protective coating and short heat cure after marking recommended.

b. Insert piece of sample or scrap wire into wire guide, and adjust pressure control until mark is sharp and clear. Impression should be just deep enough to sink slightly below surface of insulation, but should not cut into it. The pressure adjustment also controls the length of dwell in automatic machines.

c. When a satisfactory marking has been made, remove sample wire, and insert wire to be marked into wire guide, far enough so that first marking will be made about three inches from end.

d. Operate foot pedal (or hand lever) to make mark.

e. It is desirable (but not mandatory) to rotate wire 180 degrees and mark again on opposite side.

f. Mark remaining wire length. If marks are to be spaced at intervals of eight inches or less, operate machine automatically. If intervals are greater than eight inches, or if wire is larger than size No. 8 (regardless of spacing) pull wire through by hand, and operate machine at desired spacing. If practicable, rotate wire back and forth at each mark through 180 degrees to mark on opposite side. During marking procedure, check permanence of mark from time to time by rubbing with a clean dry cloth. If mark smears, or becomes hard to read, adjust machine to correct condition, and re-mark wire.

2–30. SPECIAL INSTRUCTIONS FOR MARKING TFE-INSULATED WIRE. Because of the chemical nature of TFE, it is difficult to make a permanent marking on TFE-insulated wire. Marking machines as described in 2–27 will stamp a legible marking on TFE, but this has a tendency to rub off. The marking may be set permanently by passing the marked wire through an electrically heated oven, set at a specified speed and temperature. See figure 2–13.

2–31. PROCEDURE FOR HEAT-SETTING IDENTIFICATION MARKING ON TFE. The procedure for heat-setting identification marking on TFE-insulated wire is as follows:

a. Turn the temperature control to HIGH, and allow oven to heat until temperature reaches 1900°F. (approximately 30 to 45 minutes.)

b. Turn the motor switch ON, and set speed to the desired rate; select speed from table 2–5.

c. Insert the wire through the guide tube into the forward rollers. As the first part of the wire passes through the oven, depress the rear (exit) roller manually to allow free entry of the wire into the rear guide tube; this will prevent the wire from buckling. The rest of the wire length will pass automatically through the oven.

CAUTION

Provide a suitable exhaust hood over the oven to carry off fumes. Make sure there is adequate ventilation in the area where the oven is used.

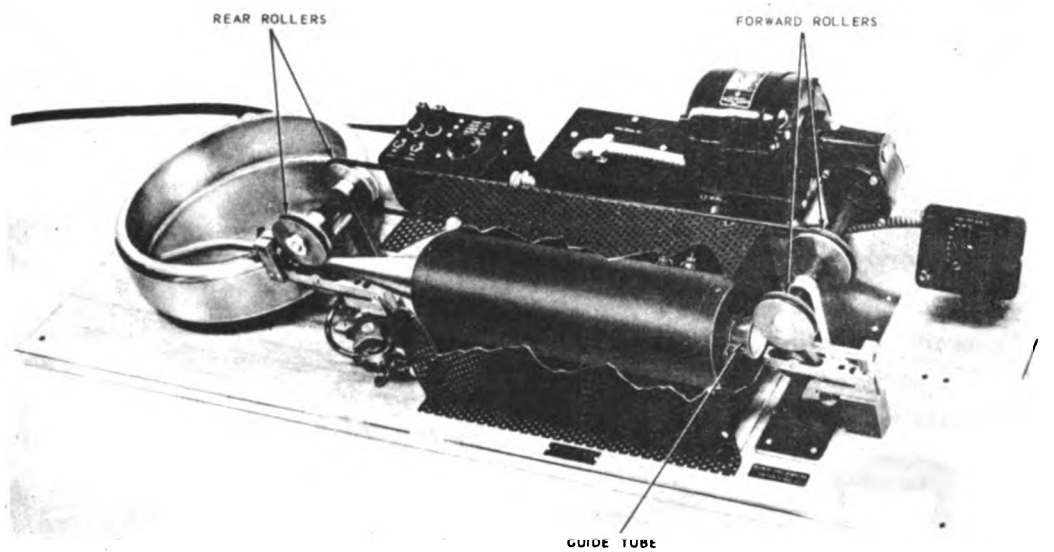


Figure 2–13. Electric Oven for Heat-Setting Identification Marking

TABLE 2–5

Speed Settings for Heat-Setting Electric Oven

Wire Specification	Wire OD.	Recommended Speed (Feet per minute)
MIL-W-7139	.070 - .090	15 to 20
	.090 - .125	10 to 15
MIL-W-16878	.050 - .070	15 to 20
	.070 - .090	12 to 15
	.090 - .125	10 to 15

2–32. SET-UP OF MARKING MACHINE FOR SLEEVE STAMPING. For stamping identification mark on tubing that has an OD of ¼ inch or smaller, use the same machine that is used for stamping wire. Set up machine as follows:

a. Select type size and wire guide to suit OD of tubing.

b. Select mandrel (metal rod) of a diameter that will fit snugly inside tubing. Insert mandrel into tubing, and both into wire guide. If mandrel of proper size is not available, use piece of insulated wire of suitable diameter and length.

c. Prepare type as described in 2–28, step a.

d. Select foil, and install wire guide, foil and type holder on machine as described in 2–28, steps b, c, and d.

2–33. PROCEDURE FOR STAMPING SLEEVES BY MACHINE. To mark tubing, follow procedure for marking wire as described in 2–29, steps a through e. After first mark, mark remaining tubing at intervals that will leave about one inch between marks (See figure 2–14). Rotate at each marking to mark again on opposite side.

2–34. MACHINE STAMPING FOR LARGE SLEEVING. See figure 2–15. To mark tubing that has OD larger than ¼ inch, use a special machine that marks tubing flat, if it is available. Flat type rather than curved type is used on this machine. Otherwise, machine set-up and marking procedure is same as that described in 2–32 and 2–33.

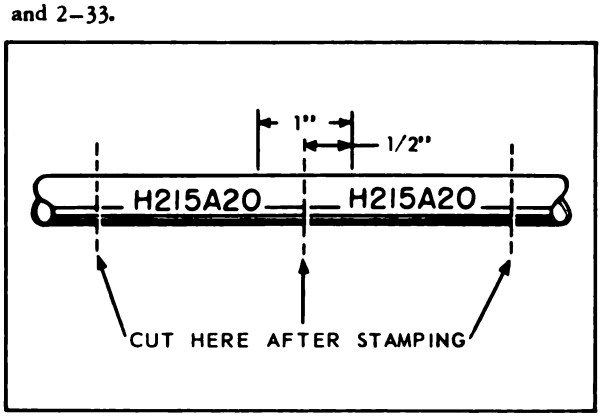


Figure 2–14. Marking on Sleeves

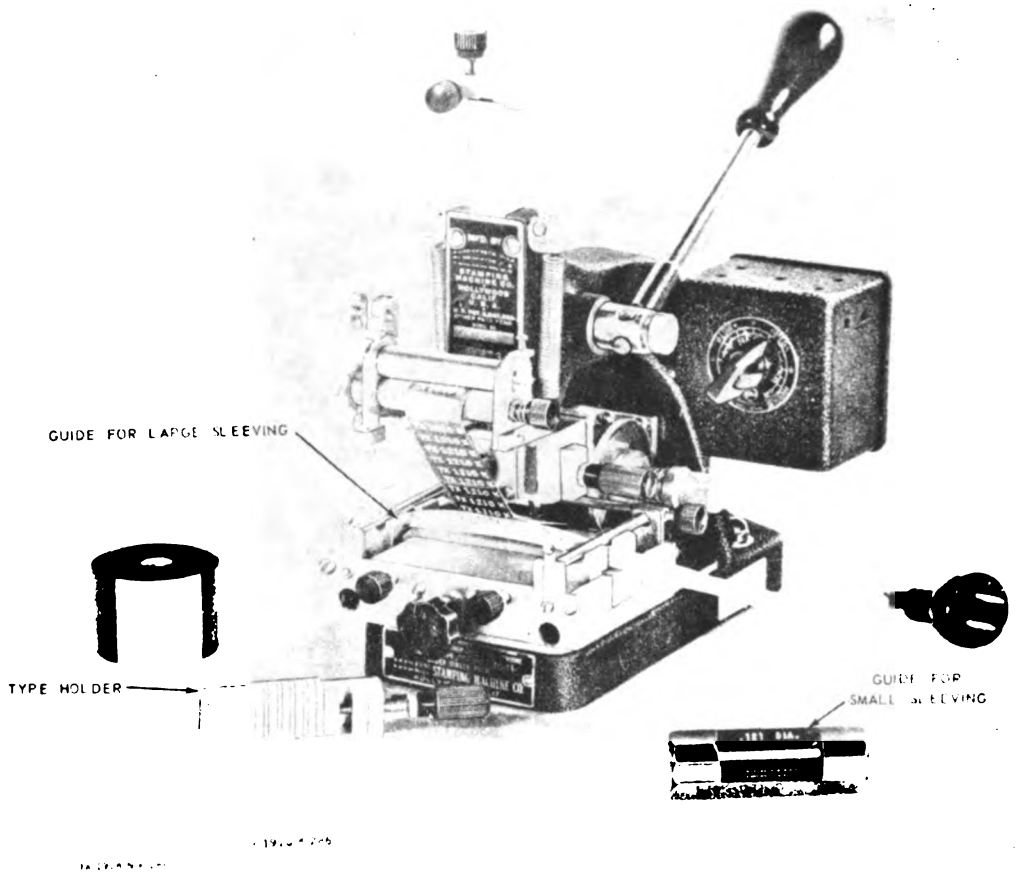


Figure 2–15. Marking Machine for Sleeving

2–35. INSTALLING IDENTIFICATION SLEEVES ON WIRING. Cut marked tubing into lengths so that marking is approximately centered (refer to figure 2–14). Install cut lengths of tubing over wire or cable at desired spacing, and tie at each end with clove hitch and square knot. See section XV for method of tying and knotting. When heat-shrinkable tubing is used, ties are not required. Before installing heat-shrinkable tubing on the wire, make sure that the wires are clean. Instructions for installation are given in section XI, paragraph 11–22.

2–36. IDENTIFICATION OF WIRE BUNDLES AND HARNESSES. See figure 2–16. Identify wire bundles and harnesses by one of the following methods:

a. If bundle is not too large select sleeving of proper size to fit snugly over wire bundle. Stamp with identification marking as described in 2–34 and install on bundle approximately 12 in. from each terminating end. Tie securely at both ends.

Note

If wires are not free at one end, sleeving must be installed on bundle before soldering wires to connectors

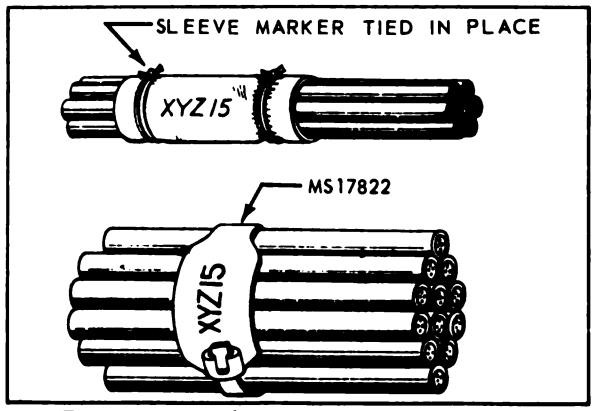


Figure 2–16. Identification of Wire Bundles & Harnesses

Heat shrinkable tubing, marked with the identification code, may also be used, installed as described in section XI, paragraph 11–22.

b. Wire bundles up to 1-¾ inch in diameter may be identified by means of an MS17822 cable identification strap which has a marking tab as part of it. See figure 2–16. The procedure is as follows:

1. Stamp the wire identification code on the marking tab as described in 2–34.

2. Pass the strap around the bundle with the ribbed side of the strap inside.

3. Insert the pointed end of the strap through the eye, and pull the strap snugly around the bundle.

4. Feed the tail of the strap through MS17823 tool, and slide tool up to eye of the cable identification strap.

5. Squeeze tool handles until strap is snug on bundle.

6. Close tool handles all the way to cut off excess the strap.

Note

Use of self-clinching adjustable plastic cable straps and installing tools is illustrated and described in section XV.

2–37. STRIPPING WIRE AND CABLE.

2–38. GENERAL. Before wire can be assembled to connectors, terminals, splices, etc., the insulation must be stripped from connecting ends to expose the bare conductor. For attachment to connectors enough insulation is stripped so that conductor will bottom in solder cup and leave a small gap between the top of the solder cup and cut end of insulation. Stripping dimensions for MS connectors will be found in section III, for RF connectors in section IV, and for terminals in section V. See figure 2–17 for typical tools used in wire stripping.

2–39 STRIPPING METHODS FOR COPPER WIRE. Copper wire may be stripped in a number of ways depending on size and insulation. See table 2–6 for a summary of wire strippers.

2–40. STRIPPING METHODS FOR ALUMINUM WIRE. Strip aluminum wires with a knife as described in 2–46. Strip aluminum wire very carefully. Take extreme care not to nick aluminum wire, as strands break very easily when nicked.

2–41. GENERAL STRIPPING INSTRUCTIONS. When stripping wire with any of the tools mentioned in 2–39 and 2–40 observe the following precautions.

a. When using hot blade stripper, make sure blades are clean. Clean blades with a brass wire brush as necessary. The hot blade stripper will not strip wire with glass braid insulation.

TABLE 2–6
Wire Strippers for Use on Copper Wire

Stripper	AN Gage No.	Insulations
Hot Blade	#26 - #4	All except asbestos and glass braid
Rotary, electric	#26 - #4	All
Bench	#20 - #6	All
Hand Pliers	#26 - #8	All, except as noted*
Knife	#2 - #0000	All

Details of each method are given in 2–42 thru 2–46.

CAUTION

*Do not use hand strippers on wires to be installed in connectors with rubber sealing grommet.

b. Make sure all stripping blades are sharp, and free from nicks, dents, etc.

c. When using any type of wire stripper, hold wire perpendicular to cutting blades.

d. Adjust automatic stripping tools carefully; follow manufacturer's instructions, to avoid nicking, cutting, or otherwise damaging any strands. This is especially important for all aluminum wires and for copper wires smaller than No. 10. Examine stripped wires for damage, and adjust tool as necessary. Cut off and restrip (if length is sufficient); or reject and replace any wires with more than the allowable number of nicked or broken strands given in table 2–7.

TABLE 2–7
Allowable Nicked or Broken Strands

Wire	Nicked or Broken Stands
Copper	
AN #22 - #12	None
#10	2
#8 - #4	4
#2 - #0	12
Aluminum, all sizes	None

Note

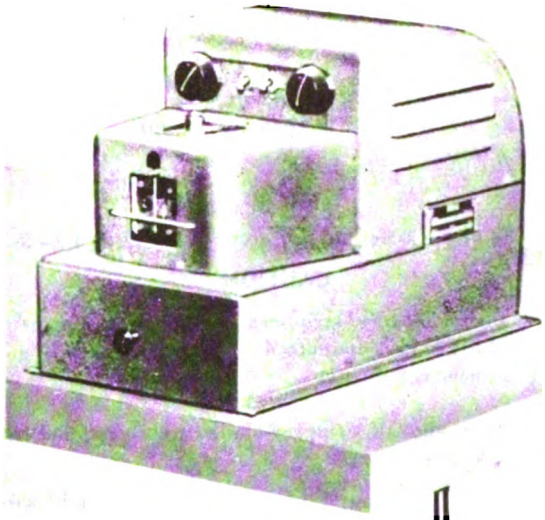
Longitudinal scratches in copper wire are not considered cause for rejection or rework.

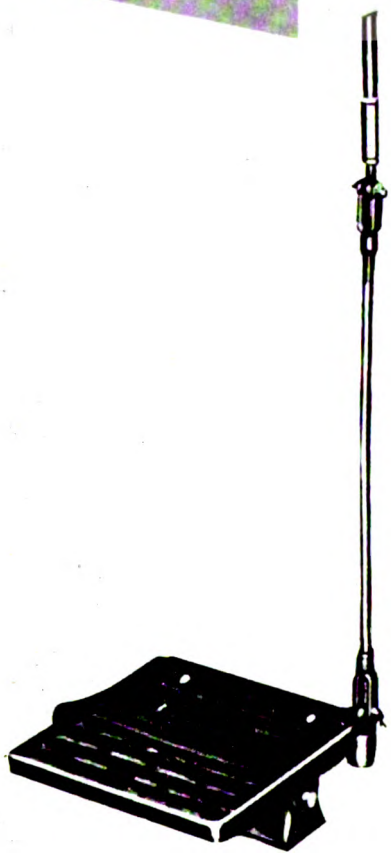
e. Make sure insulation is clean-cut with no frayed or ragged edges. Trim if necessary.

f. Make sure all insulation is removed from stripped area. Some types of wires are supplied with a clear transparent layer between conductor and primary insulation. If this is present, remove it.

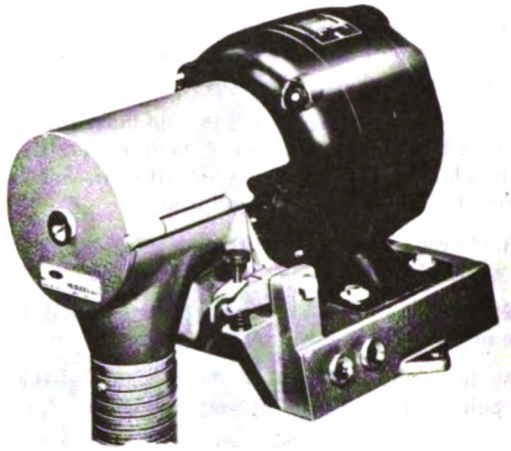
g. When using hand plier strippers to remove lengths of insulation longer than ¾ inch, it is easier to do in two or more operations

h. Retwist copper strands by hand or with pliers if necessary to restore natural lay and tightness of strands.

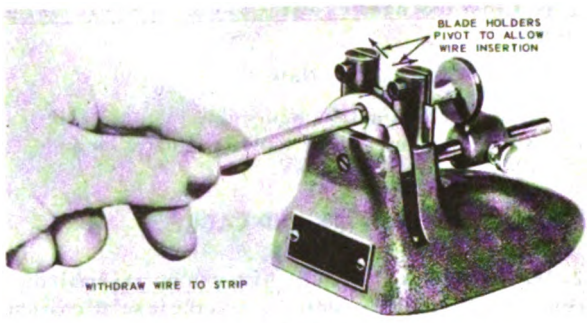




a. HOT BLADE WIRE STRIPPER



b. ROTARY WIRE STRIPPER



c. BENCH WIRE STRIPPER

d. HAND WIRE STRIPPER - HEAVY DUTY

e. HAND WIRE STRIPPER - LIGHT DUTY

Figure 2–17. Typical Wire Stripping Tools

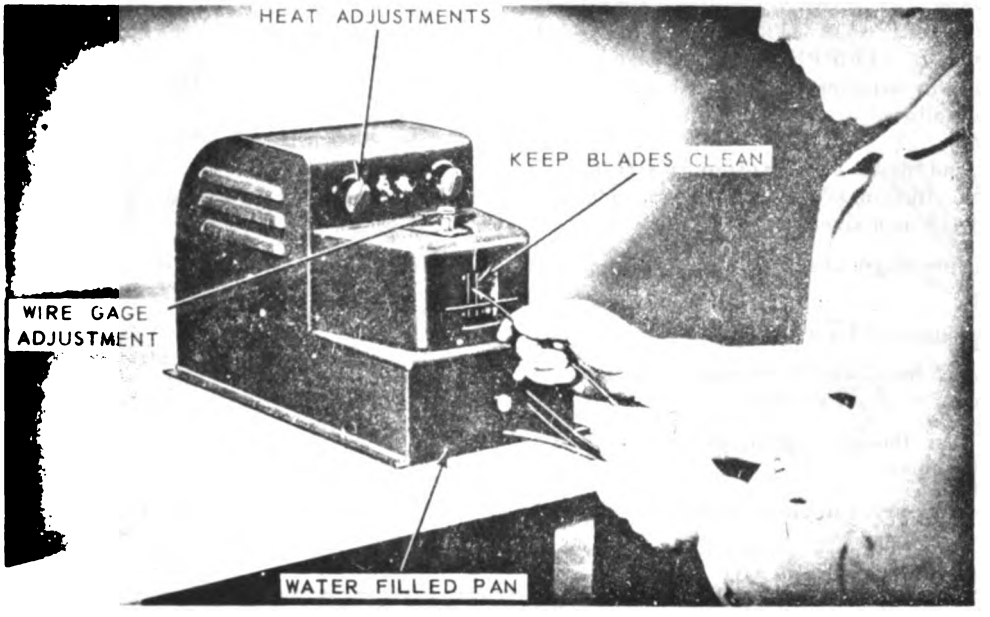


Figure 2–18. Stripping Wire in a Hot Blade Stripper

2–42. PROCEDURE FOR STRIPPING WIRE WITH HOT BLADE STRIPPER. The procedure for stripping wire with hot-blade stripper is as follows:

a. Adjust blades to correct opening for size of wire to be stripped. See figure 2–18.

b. Adjust stop by means of knurled brass nut on top of hood, for desired stripping length between ¼ inch and 1-½ inch.

c. Adjust each blade to proper heat by trying on sample pieces of wire. Use minimum heat that will remove insulation satisfactorily without damaging strands.

d. Insert wire until it butts against stop.

e. Press foot pedal to bring heated blades against insulation.

f. Twist wire about 90 degrees and pull out.

CAUTION

Make sure adequate ventilation is provided when a hot-blade stripper is used to strip TFE-insulated wire.

2–43. SUBSTITUTE HOT-BLADE STRIPPER. Where a hot-blade wire stripper is not available, a substitute can be made and used as follows: See figure 2–19.

a. In the end of a piece of copper strip, cut a sharp edged "V". At the bottom of the "V" make a wire slot of suitable diameter.

b. Fasten the copper strip around the heating element of an electric soldering iron as shown in figure 2–19.

c. Lay wire or cable to be stripped in the "V"; a clean channel will be melted in the insulation.

d. Remove insulation with slight pull.

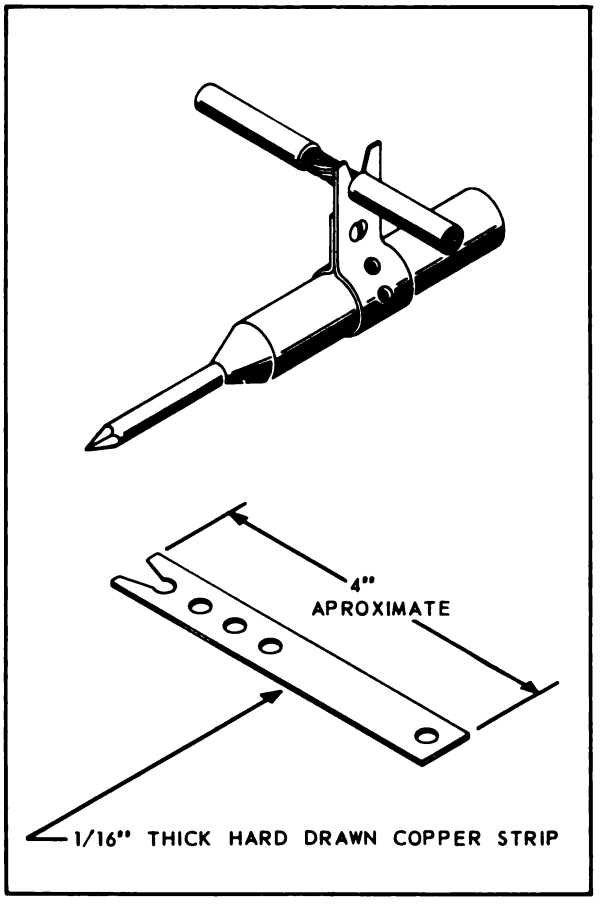


Figure 2–19. Substitute Hot Blade Stripper

2–44. PROCEDURE FOR STRIPPING WIRE WITH POWER ROTARY STRIPPER. Refer to figure 2–20. The procedure for stripping wire or cable with a rotary stripper is as follows:

a. Select and install bushing of proper size for wire to be stripped. Bushings are available in 1/8 inch, 1/4 inch and 3/8 inch sizes.

b. Set butt for length of strip desired from ¼ inch to 1-¾ inch.

c. Make adjustment for wire gage.

d. Set switch for clockwise or counterclockwise rotation according to lay of strands.

e. Insert wire through bushing until end of wire is stopped against butt.

f. Step on foot pedal to close blades on wire.

g. Pull sharply on wires to remove insulation.

h. Examine wire to be sure all insulation is removed and also that strands are not nicked or cut. Reset wire gage adjustment (step c) if necessary.

2–45. PROCEDURE FOR STRIPPING WIRE WITH HAND STRIPPER. Refer to figure 2–21. The procedure for stripping wire with plier-type hand strippers is as follows:

a. Insert wire into exact center of correct cutting slot for wire size to be stripped. (Each slot is marked with wire size).

b. Close handles together as far as they will go.

c. Release handles, allowing wire holder to return to open position.

d. Remove stripped wire.

Note

Jaws will not snap back until wire is removed.

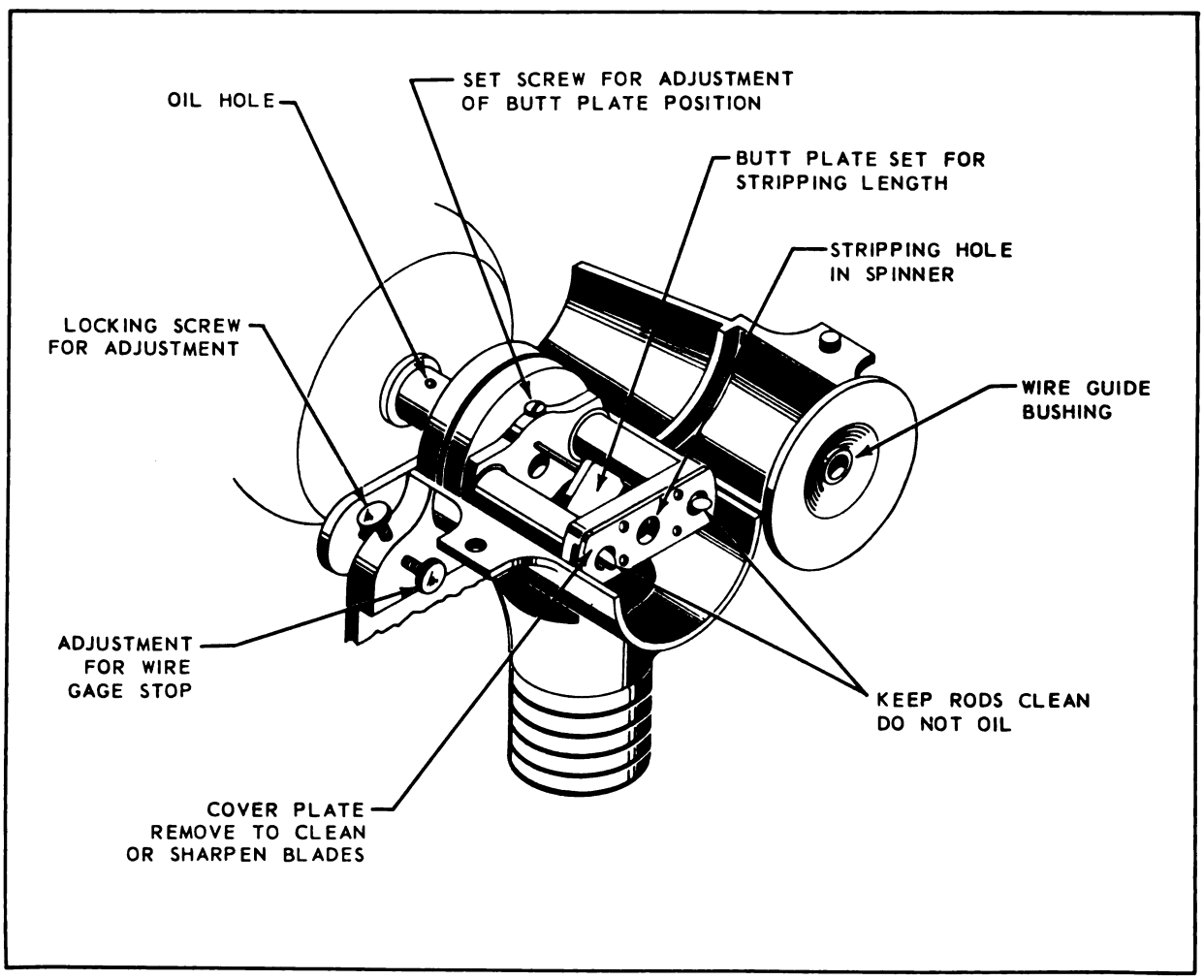


Figure 2–20. Inside View of Rotary Wire Stripper

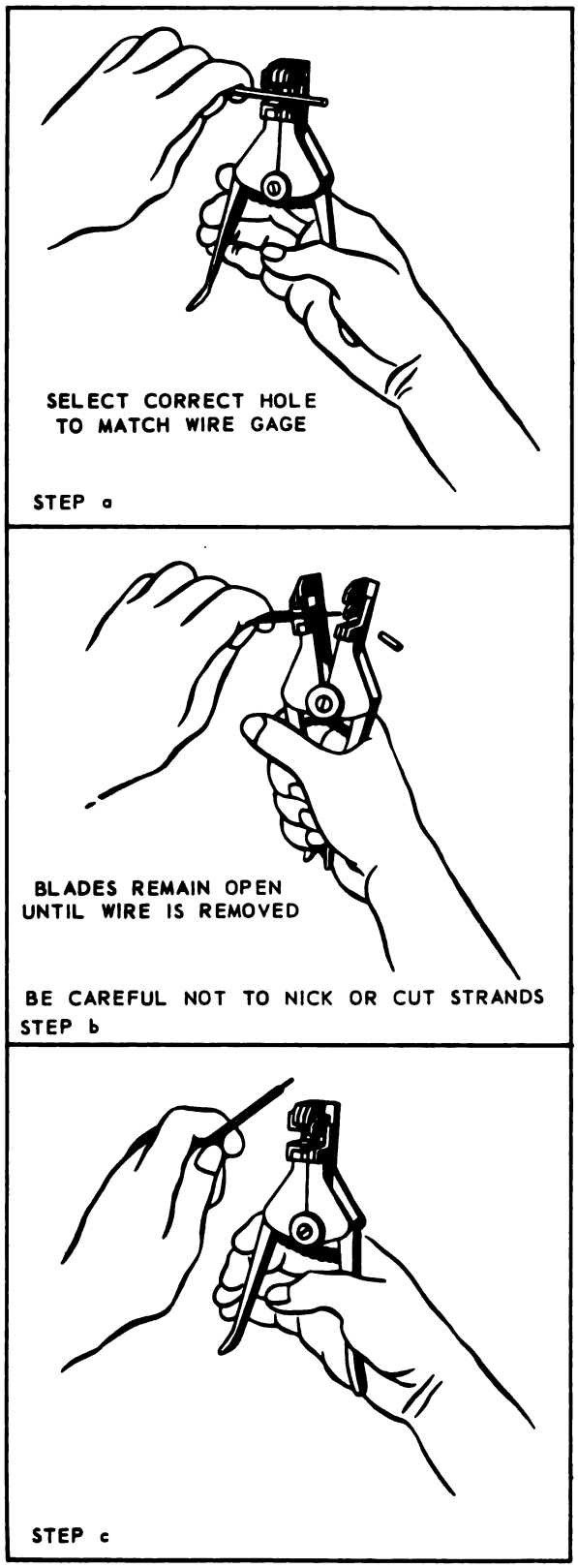


Figure 2–21. Stripping Wire With Hand Stripper

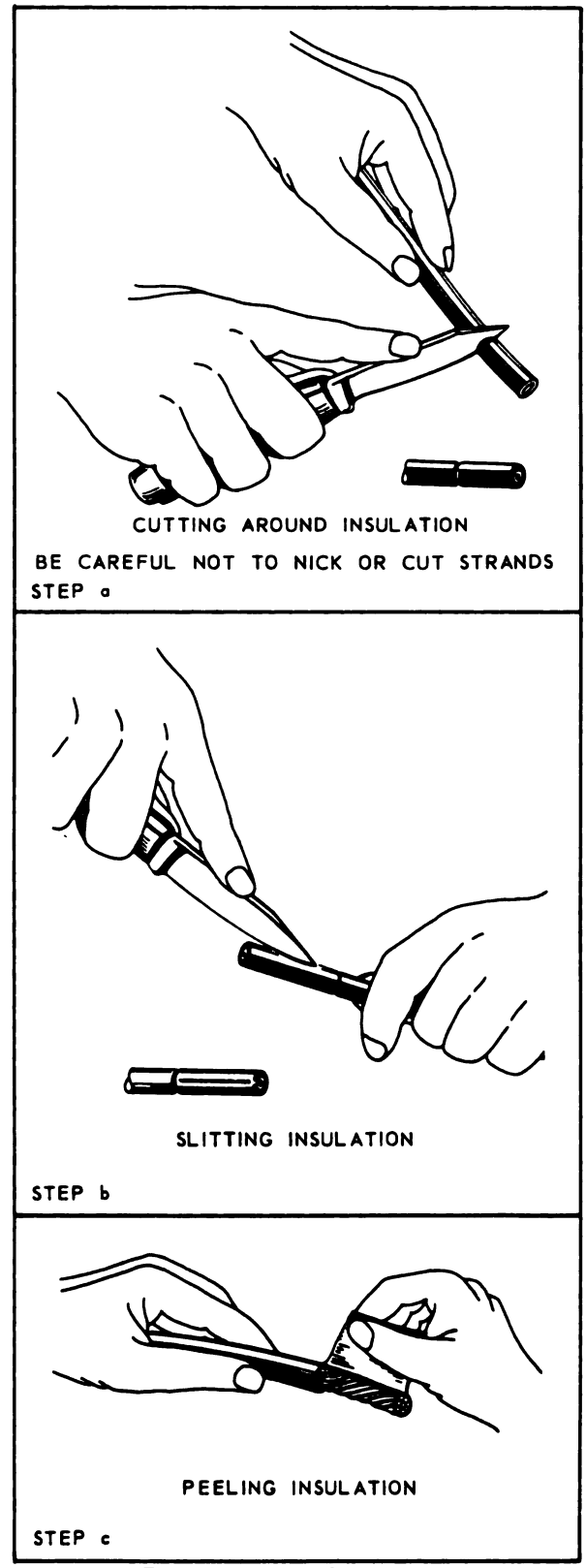


Figure 2–22. Knife Stripping

2-46. PROCEDURE FOR STRIPPING WIRE WITH A KNIFE. See figure 2-22. The procedure for stripping wires with a knife is as follows:

CAUTION

Take care not to nick or cut strands.

a. Make cut around wire at desired strip length. Do not cut completely through the insulation.

b. Make second cut lengthwise along stripping length. Do not cut completely through insulation.

Note

When a wire has two or more layers of insulation, cut through outer layers and only score innermost.

c. Peel off insulation, following lay of strands.

2-47. STRIPPING DIMENSIONS FOR ASSEMBLY TO CONNECTORS. Stripped length on wires which are to be attached to connectors should be such that when stripped conductor bottoms in solder cup there will be a gap of approximately 1/32 in. between the end of the cup and the end of the insulation, for inspection purposes.

2-48. TINNING COPPER WIRE AND CABLE.

2-49. GENERAL. Before copper wires are soldered to connectors the ends exposed by stripping are tinned to hold the strands solidly together. The tinning operation is considered satisfactory when the ends and sides of the wire strands are fused together with a coat of solder. Do not tin wires which are to be crimped to Class K (fireproof) connectors, wires which are to be attached to solderless terminals or splices, or wires which are to be crimped to removable crimp-style connector contacts.

2-50. TINNING METHODS. Copper wires are usually tinned by dipping into flux and then into a solder bath. In the field, copper wires can be tinned with a soldering iron and rosin core solder.

2-51. EXTENT OF TINNING. Tin conductor for about half its exposed length. This is enough to take advantage of closed part of solder cup. Tinning or solder on wire above cup causes wire to be stiff at point where flexing takes place. This will result in wire breakage.

2-52. PREPARATION OF FLUX AND SOLDER. The flux used to tin copper wire is a mixture of denatured alcohol and freshly ground water-white rosin in the proportion of eight ounces of alcohol to one ounce of rosin, mixed together thoroughly and well shaken. During use the alcohol will evaporate and should be replaced. The solder used is a mixture of 60% tin and 40% lead. Maintain temperature of the solder pot between 450 and 500 degrees F; this will keep solder in a liquid state. Skim surface of solder pot as necessary with a metal spoon or blade to keep solder clean and free from oxides, dirt, etc.

CAUTION

Do not use any other flux or solder for tinning copper wires for use in aircraft electrical systems.

2-53. DIP-TINNING PROCEDURE. See figure 2-23. Dip-tin wires smaller than No. 8 about eight or ten at a time. Dip-tin wires size No. 8 and larger individually.

CAUTION

During tinning operation, take care not to melt, scorch or burn the insulation.

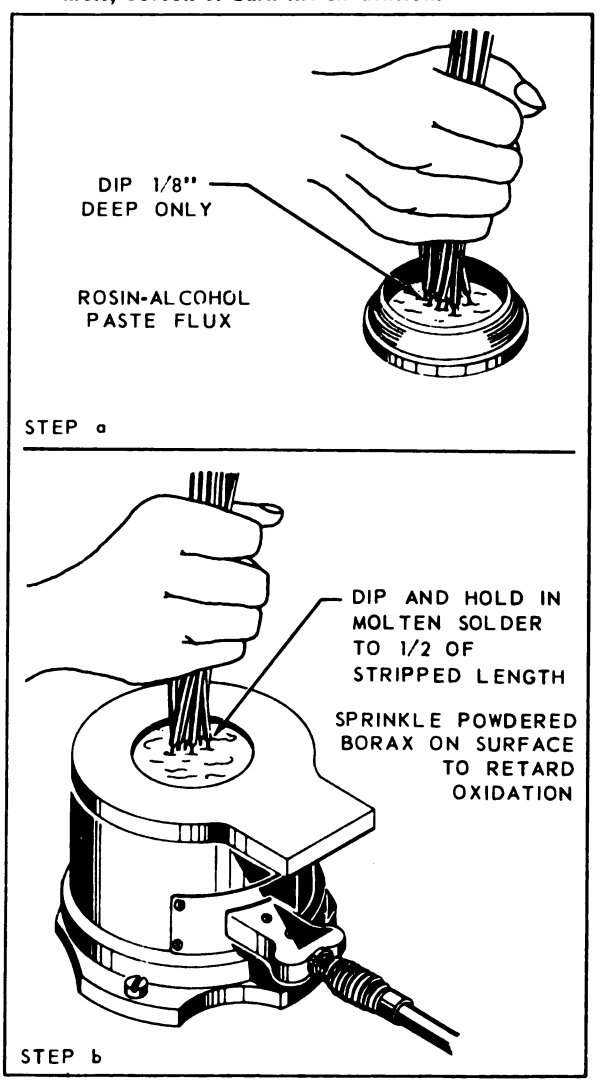


Figure 2-23. Dip Tinning in Solder Pot

The procedure for dip-tinning is as follows:

a. Prepare flux and solder as described in 2–52.

b. Make sure that exposed end of wire is clean and free from oil, grease and dirt. Strands should be straight and parallel. Dirty wire should be restripped.

c. Grasp wire(s) firmly and dip into dish of prepared flux to a depth of about 1/8 inch.

d. Remove wire and shake off excess flux.

e. Immediately dip into molten solder. Dip only half of stripped conductor length into solder.

f. Manipulate wires slowly in solder bath until they are thoroughly tinned. Watch the solder fuse to wire. Do not keep wire (s) in bath longer than necessary.

g. Remove wires and shake off excess solder.

Note

The thickness of the solder coat depends on the speed with which the wires are handled and shaken, and the temperature of the solder bath.

2–54. ALTERNATE DIP-TINNING PROCEDURE. See figure 2–24. If an electrically heated solder pot is not available, a small number of wires may be tinned by means of the following procedure:

a. Cut off beveled section of tip of a discarded soldering iron tip.

b. Drill hole (¼ to 3/8 inch diameter) in cylindrical part of tip, about two thirds through.

c. Heat up iron, and melt rosin-core solder into hole.

d. Tin wires by dipping into molten solder one at a time.

e. Keep adding fresh rosin-core solder as the flux burns away.

2–55. PROCEDURE FOR SOLDERING IRON TINNING. See figure 2–25. In the field wires smaller than size No. 10 may be tinned with a soldering iron and rosin core solder as follows:

a. Select a soldering iron having suitable heat capacity for wire size from table 2–8. Make sure that iron is clean and well-tinned.

TABLE 2–8

Approximate Soldering Iron Sizes for Tinning

Wire Size (AN Gage)	Soldering Iron Size (Heat Capacity)
#20 - #16	65 Watts
#14 & #12	100 Watts
#10 & #8	200 Watts

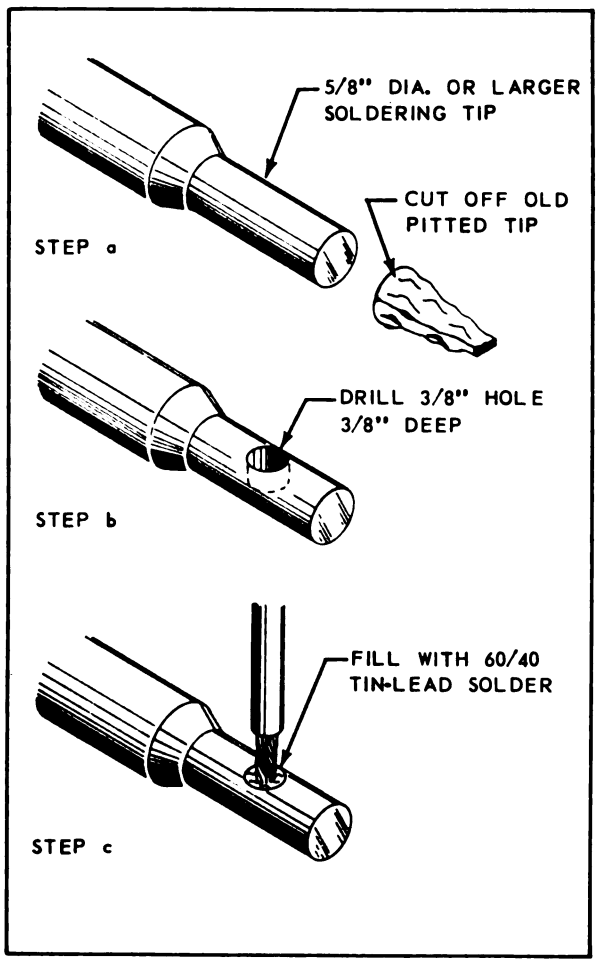


Figure 2–24. Alternate Dip-Tinning Method

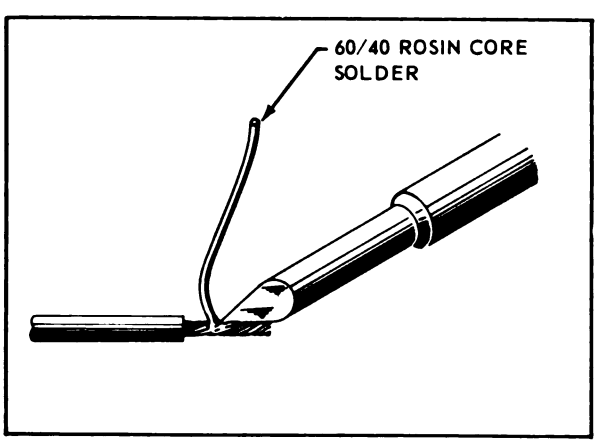


Figure 2–25. Tinning Wire With a Soldering Iron

b. Prime by holding iron tip and solder together on wire until solder begins to flow.

c. Move soldering iron to opposite side of wire and tin half of the exposed length of conductor.

2–56. TERMINATING SHIELDED CABLE.

2–57. GENERAL. Shielded cable has a metallic braid over the insulation to provide a barrier around the conductor through which electro-static energy (noise or interference) cannot pass. To obtain satisfactory result from shielded cable, the shield must be unbroken and must extend to a point as near the end of the conductor as practicable. Shielded cable is either grounded or dead-ended at each end as required by the individual installation. The following paragraphs describe these procedures.

2–58. STRIPPING JACKET ON SHIELDED CABLE. Some shielded cable has a thin extruded plastic coating over the shielding braid. Strip this off as far as necessary with a hot blade stripper, as described in 2–42 or 2–43. Length of strip depends on method of shield termination and type of wire connection. Strip outer jacket back far enough for ease in working. If no hot-blade stripper is available, use plier type hand strippers for sizes No. 22 through No. 10, and a knife for sizes larger than No. 10. Be careful not to damage shielding braid. Extruded jacket of shielded twisted wires can also be stripped by holding a soldering iron, with tip removed, against jacket, and pulling off jacket with long nose pliers as iron melts jacket. See figure 2–26.

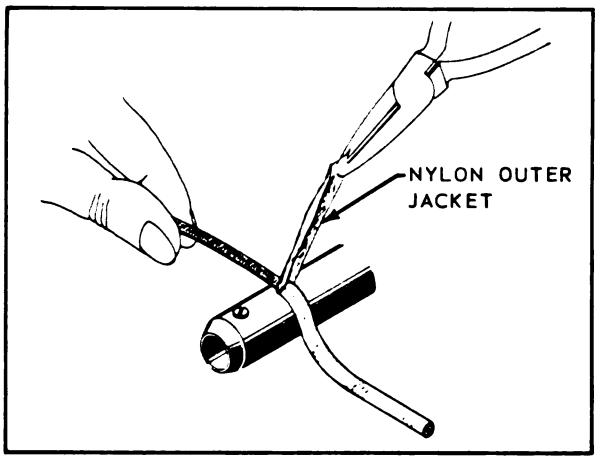


Figure 2–26. Stripping Outer Jacket from Shielded Cable

2–59. ONE-PIECE GROUNDING FERRULE METHOD OF SHIELD TERMINATION. When the metallic braid of shielded cable can easily be flared out, the preferred method of terminating the shield is by crimping it, with or without a ground wire as required, into a one-piece insulated ferrule. Use the standard shield grounding ferrule MS25311, and the standard crimping tool MS25312. The procedure is as follows: (See figure 2–27).

a. Determine the diameter of the insulation directly under the shield

b. Select the ferrule having the nearest larger ID from table 2–9.

c. Strip shield braid (and outer jacket if present) 5/16 to 3/8 inch with hand strippers or scissors.

d. Strip outer jacket (if present) 1/2 to 3/4 inch, being careful not to nick braid strands.

e. Fan metal braid slightly by rotating inner conductor.

f. Insert inner conductor through inner ring. Slide inner ring under the metal braid and outer ring over the metal braid.

g. If ground wire is required, use AN20 or AN22 wire, stripped 5/16 to 3/8 inch.

h. The shield braid must be visible through one of the inspection holes. The ground lead should be visible through the inspection hole on the side where the ground lead was inserted.

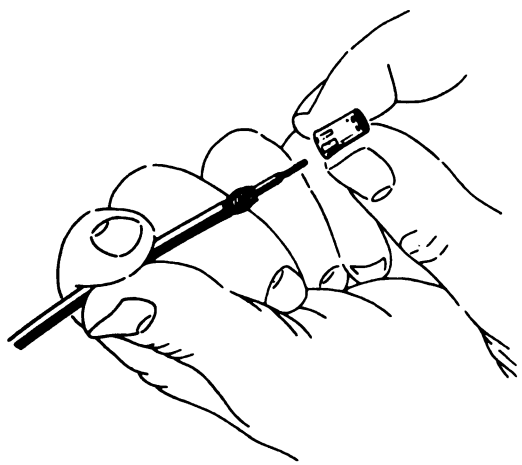
i. Position the ferrule flush against the stop plate of the correct crimping tool selected from table 2–9. Make sure the inspection holes are in the vertical position in line with direction of the crimp.

j. Close the handles of the tool all the way until the ratchet releases. Remove ferrule from tool.

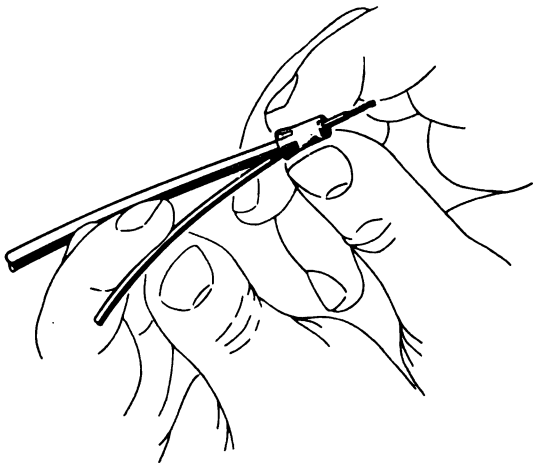
TABLE 2–9

Standard (MS) One Piece Shielded Wire Terminations and Installing Tools

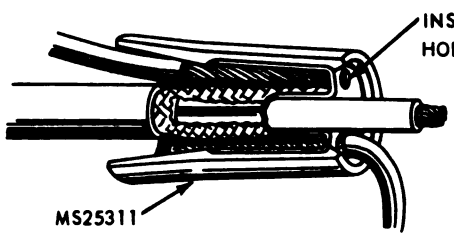
MS Part Number	Color Code	Insulation OD Under Shield	Ferrule ID	Tool
MS25311- 90	Red	.050 - .040	.058	MS25312-2
-100	Yellow	.055 - .045	.063	-1
-110	Blue	.072 - .052	.080	-1
-120	Green	.093 - .069	.102	-1
-130	Black	.107 - .090	.115	-2
-150	Green	.126 - .104	.134	-3
-160	Red	.148 - .122	.156	-3
-180	Blue	.171 - .143	.179	-4
-200	Yellow	.202 - .166	.210	-4



STEPS a THROUGH e

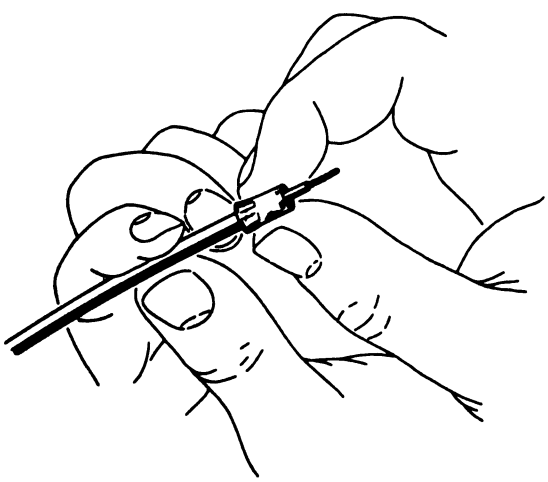


STEP g

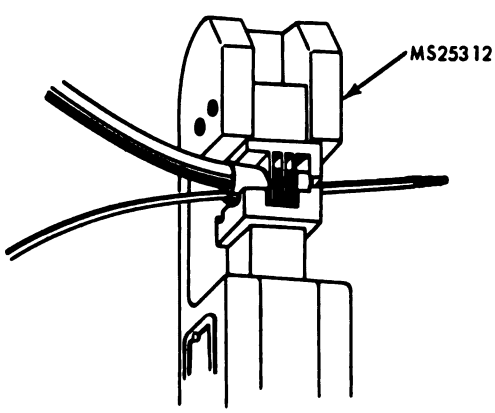


SECTIONAL VIEW OF COMPLETED CONNECTION SHOWING GROUND WIRES INSERTED AT EITHER END OF FERRULE

STEP h



STEP f



STEPS i and J

Figure 2–27. One Piece Grounding Connection for Terminating Shielded Wire

2–60. STANDARD MS HAND TOOL INSPECTION. The MS25312 hand tool is checked with gages for the proper adjustment of the crimping jaws; check the tool before each series of crimping operations. The standard MS tool is checked with the standard gage MS25316. The dash number of the gage corresponds to the groove dash number of the die it will check. Check the standard tool dies with the tool fully closed; the GO gage should be able to enter between the jaws; the NO GO gage should not be able to enter.

2–61. TWO-PIECE GROUNDING SHEATH CONNECTOR METHOD OF SHIELD TERMINATION. See figure 2–28. The metallic braid of shielded cable can also be terminated with a two-piece grounding sheath connector, by crimping it, with or without a ground wire as required, between two ferrules (or sleeves). Use the standard MS inner and outer ferrules listed in tables 2–10, 2–11, and 2–12 and the tools listed in the tables. The procedure is as follows:

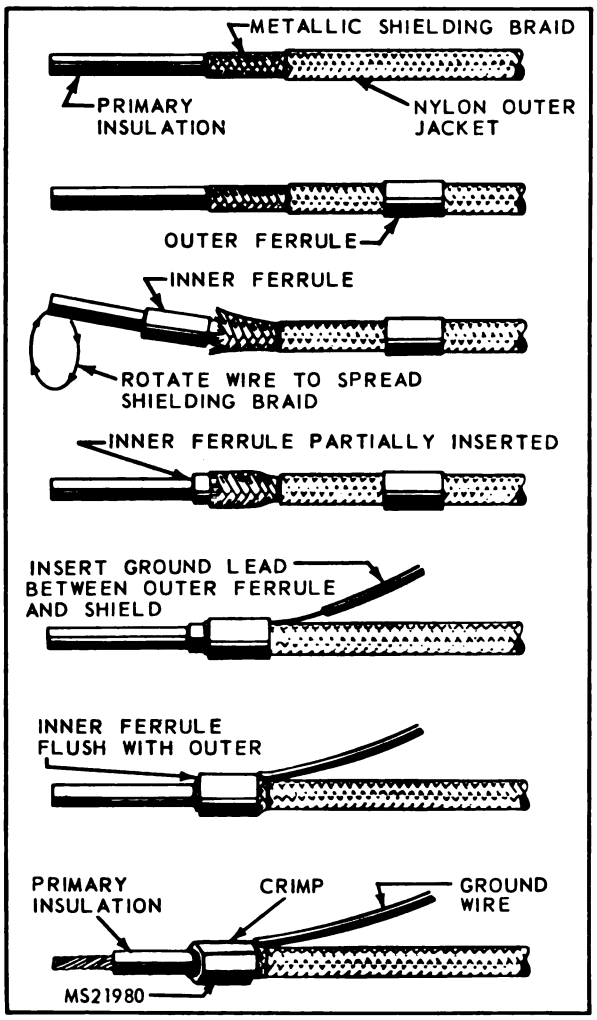


Figure 2–28. Two Piece Grounding Connection for Terminating Shielded Wire

a. Strip off shielding braid (and outer jacket if present) with hand strippers or scissors. Length to be stripped is determined by length of unshielded conductor necessary for making connection.

b. Strip outer jacket (if present) 1/2 to 3/4 inch.

c. Measure OD of insulation directly under shield.

d. Add .005 inch minimum to OD obtained in step c, and select inner sleeve having the nearest larger ID from table 2–10.

e. Note OD of inner sleeve selected in step d, and add .025 inch minimum to it to allow for thickness of shielding braid. Add an extra .030 to .040 to allow clearance for a No. 20 or No. 18 ground wire if required. From tables 2–11 or 2–12 select an uninsulated or insulated outer sleeve as required, with the above dimension as minimum ID.

f. Slide outer sleeve back over insulation and braid.

g. Rotate cable with circular motion to flare out braid.

h. Slip inner sleeve under braid so that about 1/16 inch of sleeve sticks out beyond braid.

i. Insert stripped ground wire under outer sleeve (if required) and slide both forward over braid and inner sleeve until only 1/32 to 1/16 inch of inner sleeve and braid protrude. See figure 2–28. Ground wire may extend from front or back of outer sleeve as required.

CAUTION

Examine assembly to make sure that shield braid and ground wire come through under the outer sleeve.

j. Crimp with hand tool selected from tables 2–11 or 2–12.

2–62. The above procedure may be modified by sliding the inner ferrule over the braid, and folding the braid neatly back over the inner ferrule (See figure 2–29). If this is to be done, add an additional .025 inch to the dimension obtained in 2–61, step d for the extra braid thickness.

2–63. PIGTAIL METHOD OF SHIELD TERMINATION. When grounding sheath connectors and tools are not available, terminate shield for grounding by making a pigtail as follows: See figure 2–30.

CAUTION

Take extreme care not to damage shielding or insulated conductor while forming pigtail.

a. Determine and mark point shielding is to terminate. This depends on the individual installation.

b. Push back shielding to form a bubble at the termination point.

c. Insert an awl, or other pointed tool into shielding braid at termination point and work an open circular area in the shield. Be careful not to cut into wire insulation.

d. Bend cable, insert tool between shielding and wire, and pull insulated conductor through hole formed by tool.

e. Pull empty part of shield taut and tin last inch to prevent fraying.

f. On unjacketed shielded cable, spot tie shielding on cable with clove hitch and square knot. This is not necessary if cable has extruded plastic jacket over shield.

TABLE 2–10

Shielded Wire Terminations – Inner Sleeves

Part Number	Color Code	Insulation OD Under Shield	Inner Sleeve (nominal) ID	Inner Sleeve (nominal) OD
MS21981 - 046	Tin	.031 - .041	.046	.070
- 058	Yellow	.043 - .053	.058	.083
- 063	Red	.048 - .058	.063	.088
- 071	Green	.056 - .066	.071	.096
- 080	Blue	.065 - .075	.080	.104
- 090	Orange	.075 - .085	.090	.114
- 096	Purple	.081 - .091	.096	.119
- 101	Yellow	.091 - .096	.101	.124
- 109	Red	.096 - .104	.109	.131
- 115	Tin	.104 - .110	.115	.146
- 124	Green	.110 - .119	.124	.145
- 128	Tin	.110 - .123	.128	.152
- 134	Orange	.123 - .129	.134	.156
- 149	Blue	.129 - .144	.149	.179
- 156	Red	.145 - .151	.156	.192
- 165	Tin	.151 - .160	.165	.194
- 175	Green	.160 - .170	.175	.215
- 187	Yellow	.175 - .182	.187	.227
- 194	Blue	.182 - .189	.194	.225
- 205	Orange	.189 - .200	.205	.245
- 219	Tin	.200 - .214	.219	.248
- 225	Yellow	.214 - .220	.225	.256
- 232	Red	.220 - .227	.232	.263
- 250	Green		.250	.281
- 261	Blue	.227 - .255	.261	.297
- 266	Tin	.261 - .271	.266	.297
- 275	Orange	.255 - .270	.275	.306
- 281	Yellow	.270 - .276	.281	.331
- 287	Tin	.276 - .282	.287	.327
- 297	Red	.282 - .292	.297	.336
- 312	Purple	.292 - .307	.312	.362
- 375	Blue	.370 - .380	.375	.406

TABLE 2-11

Shielded Wire Terminations - UNINSULATED Outer Sleeves and Installing Tools

Part Number	Color Code	Sleeve ID (Inches) Nominal	Installing Tools (Thomas & Betts)
MS21980 - 101	Tin	.101	WT - 219
- 128	Blue	.126	- 200
- 149	Purple	.149	- 201
- 156	Yellow	.156	- 202
- 175	Blue	.175	- 203
- 187	Orange	.187	- 206
- 194	Red	.194	- 206
- 199	Tin	.199	- 206
- 205	Yellow	.206	- 208
- 219	Green	.219	- 208
- 225	Purple	.225	- 209
- 232	Orange	.233	- 210
- 261	Yellow	.261	- 211
- 275	Tin	.275	- 212
- 281	Purple	.281	- 214
- 287	Blue	.287	- 214
- 299	Green	.299	- 214
- 312	Yellow	.312	- 215
- 327	Tin	.327	- 216
- 346	Orange	.346	- 217
- 359	Purple	.359	- 221
- 375	Yellow	.375	- 222
- 405	Red	.405	- 218
- 415	Blue	.415	- 218
- 460	Tin	.460	- 220
- 500	Green	.500	- 223

2-64. ALTERNATE PIGTAIL METHOD. See figure 2-31. Some shielding braids may be too stiff for the method described in 2-63. In this case, cut shielding with scissors approximately 1-1/2 inches forward of termination point. Comb out strands with comb (see figure 2-32) or pointed bakelite rod. Twist strands into pigtail, or separate strands into three parts, twist each part, and braid together. Tie with cord as described in 2-63 step f.

TABLE 2-12

Shielded Wire Terminations – INSULATED Outer Sleeves and Installing Tools

Part Number	Color Code	Sleeve ID (Inches) Nominal	Installing Tools (Thomas & Betts)
MS18120 - 101	Tin	.101	WT - 200
- 128	Blue	.128	- 201
- 149	Purple	.149	683 - 51135
- 156	Yellow	.156	WT - 206
- 175	Blue	.175	- 208
- 187	Orange	.187	- 210
- 194	Red	.194	- 210
- 199	Tin	.199	- 210
- 205	Yellow	.205	- 211
- 219	Green	.219	- 211
- 225	Purple	.225	- 211
- 232	Orange	.232	- 212
- 261	Yellow	.261	- 214
- 275	Tin	.275	- 215
- 281	Purple	.281	- 217
- 287	Blue	.287	- 217
- 297	Green	.297	- 217
- 312	Yellow	.312	- 222
- 327	Tin	.327	- 222
- 348	Orange	.348	683 - 51014
- 359	Purple	.359	WT - 216
- 375	Yellow	.375	683 - 51 - 15
- 405	Red	.405	683 - 51141 - 1
- 415	Blue	.415	683 - 51141 - 1
- 460	Tin	.460	683 - 51141 - 2
- 500	Green	.500	683 - 51141 - 3

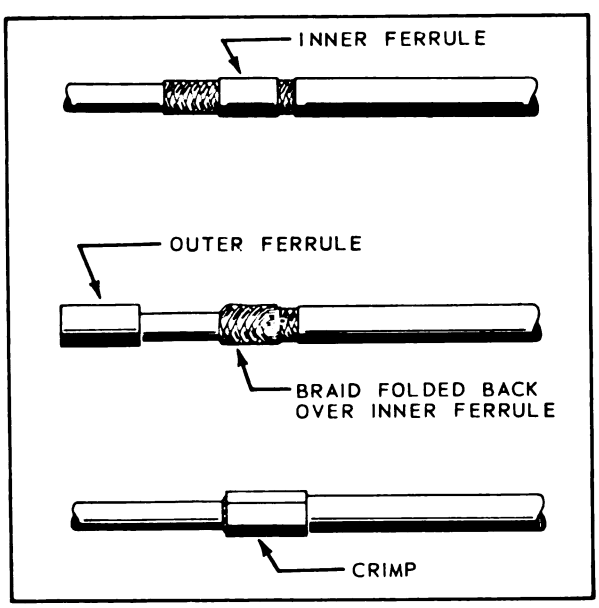


Figure 2-29. Alternate Procedure for Two Piece Grounding Sheath Connector

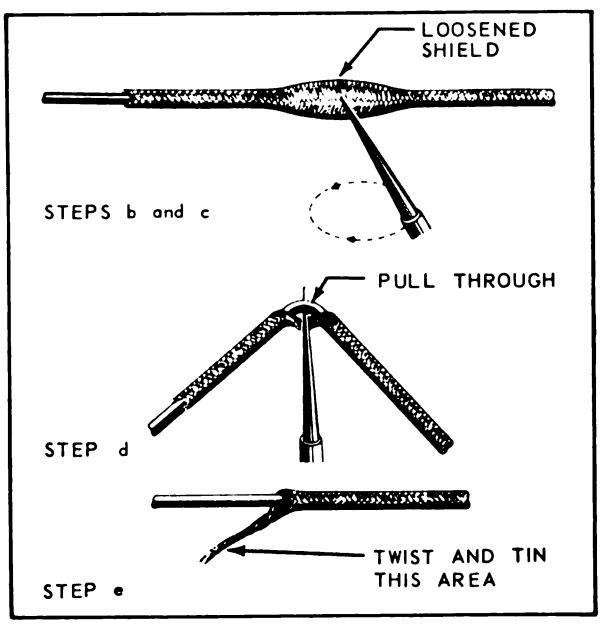


Figure 2-30. Pigtail Termination for Shielded Wire

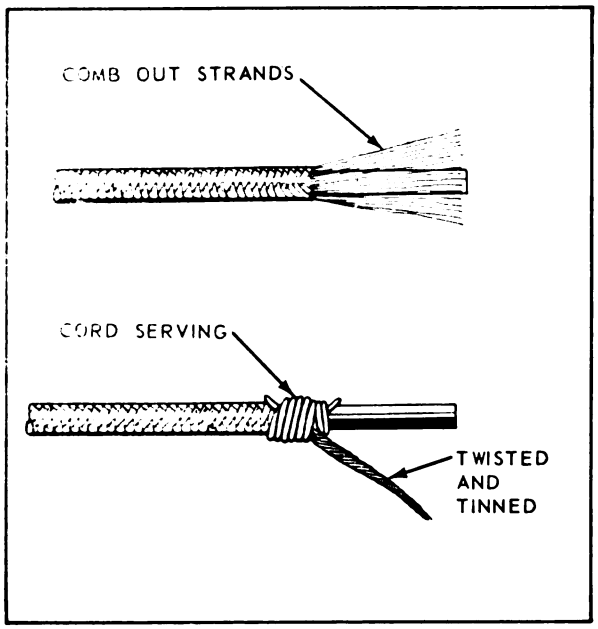


Figure 2–31. Alternate Pigtail Termination for Shielded Wire

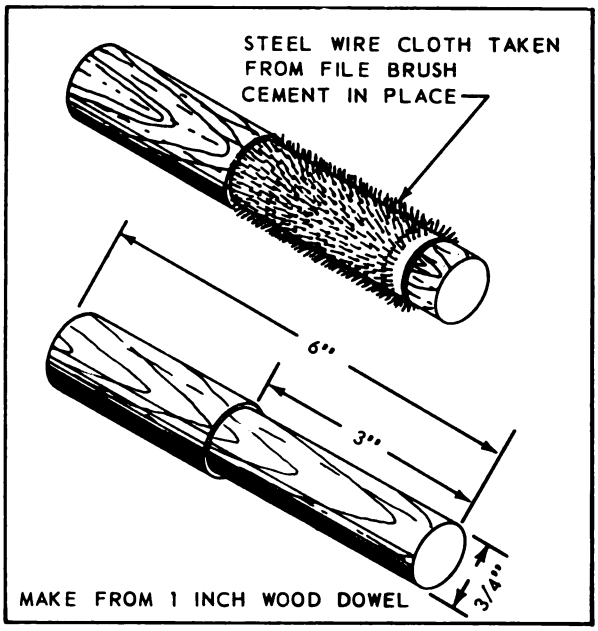


Figure 2–32. Comb for Combing Out Shield

2–65. DEAD-ENDING SHIELDED CABLE. When the shielding is not to be grounded, it is dead-ended so as to gather all loose shield ends together to prevent them from puncturing insulation.

2–66. DEAD-ENDING WITH GROUNDING SHEATH CONNECTOR. When equipment is available, dead-end shielded cable with grounding sheath connector as described in 2–59, or 2–61, omitting ground wire. Refer to figures 2–27 or 2–28. Omit clearance allowed for ground wire when selecting outer sleeve.

2–67. DEAD-ENDING WITH TAPE WRAP. When grounding sheath connector and tools are not available, dead-end shielding as follows: See figure 2–33.

a. Cut shielding braid with scissors about 3/4 inch forward of termination point.

b. Loosen braid and turn back on itself 3/4 inch.

c. Wrap with two or three turns of plastic tape, making sure that all braid ends are covered.

d. Tie loose end of tape with clove hitch and square knot, or heat seal end of tape with untinned side of soldering iron. A plastic wire strap or tie, as described in section XV may be used instead of tying cord to secure the loose end of the tape.

2–68. ALTERNATE METHODS OF DEAD-ENDING. As alternate to method described in 2–66, make pigtail as described in 2–63 or 2–64, and trim pigtail so it is 3/4 inch long. Crimp trimmed pigtail into one end of preinsulated permanent splice of suitable size, and tie back on shielded part of cable. See figure 2–34. If permanent splice is not available, cut tongue off solderless terminal of suitable size, and crimp pigtail into it. Protect with sleeve and tie back on wire, similar to tie used with permanent splice.

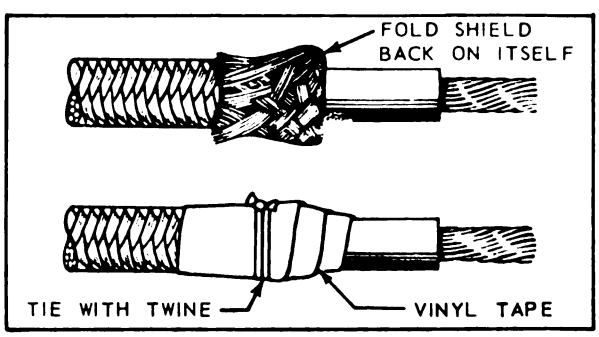


Figure 2–33. Dead-Ending Shield with Tape Wrap

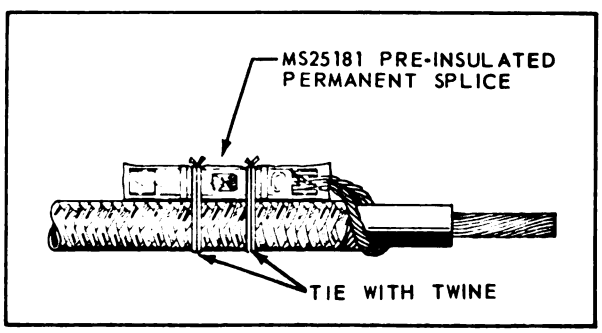


Figure 2–34. Dead-Ending Shielding with Permanent Splice

SECTION III

GENERAL PURPOSE CONNECTORS

3–1. INTRODUCTION.

3–2. GENERAL. Connectors provide means of quickly connecting and disconnecting wires to simplify installation and maintenance of electric and electronic equipment.

3–3. SCOPE. This section describes and illustrates the types and classes of Military Standard connectors and the recommended procedures for attaching wires to connector contacts. AN type connectors were formerly designated with the prefix "AN", and older connectors may still be found with this prefix. The superseding connector has the same part number except that the "AN" has been replaced by "MS". Other connectors, commonly used in aircraft, similar to MS connectors, are also described and illustrated in this section. RF connectors are treated separately in section IV.

3–4. REFERENCE SPECIFICATIONS, DRAWINGS AND DOCUMENTS.

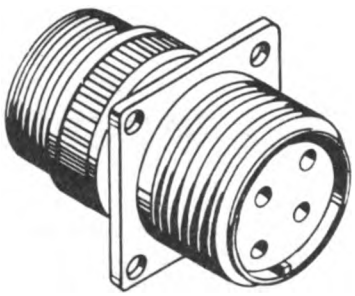
VV–P–236	Petrolatum, Technical
QQ–S–571	Solder, Lead Alloy, Tin Lead Alloy and Tin Alloy
MIL–I–631	Insulation, Electrical, Synthetic-Resin Composition, Non-Rigid
MIL–T–713	Twine, Lacing and Tying, Electrical and Electronic Equipment
MIL–C–5015	Connectors, Electrical, AN Type
MIL–W–5088	Wiring, Aircraft, Installation of
MIL–C–5649	Cord, Cotton, Braided, Pre-Waxed
MIL–A–6091	Alcohol, Ethyl, Specially Denatured, Aircraft
MIL–S–6872	Soldering Process, General Specification for
MIL–D–6998	Dichloromethane, Technical
MIL–I–7444	Insulation Sleeving, Electrical, Flexible
MIL–S–8516	Sealing Compound, Synthetic Rubber, Electric Connectors and Electric Systems, Accelerator Required
MIL–I–18057	Insulation Sleeving, Electrical, Flexible, Glass Fiber, Silicone Rubber Treated
MIL–T–22520	Tool, Crimp Type, for Contacts of Electrical Connectors
MIL–C–23216	Contacts, Crimp Type, Electric Connector, General Specification for
MIL–C–26482	Connectors, Electric, Circular, Miniature, Quick Disconnect
MIL–C–26500	Connectors, General Purpose, Electrical, Miniature, Circular, Environment Resisting, 200°C Ambient
MIL–C–26636	Contacts, Crimp Type, for Electrical Connectors
MS3103	Connectors - Receptacle, Electric, for Potting
MS3191	Tool, Hand, Crimp, Class I-for Contacts of Electric Connectors
MS3196	Gage, Inspection, for Contact Crimping Tool
MS24256	Tool-Contact Connector, Assembly and Disassembly
MS25183	Connector, Plug, Electric for Potting
MS 25274	Cap, Wire End (Class I)

Navy-BuWeps EMC No. 89-55- Electric Connector Sealing

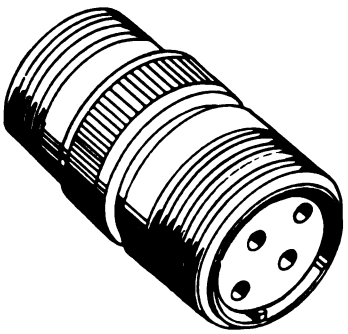
3–5. DESCRIPTION.

3–6. GENERAL DESCRIPTION OF AN-MS CONNECTORS. Each complete AN-MS connector consists of two parts: a plug assembly and a receptacle assembly coupled by means of a coupling device which is part of the plug assembly. Standard AN type connectors are coupled with a threaded coupling ring except for MS3107, which has a friction coupling. Miniature MS connectors, a smaller lightweight version of the AN type connector, are coupled by means of a threaded ring, a bayonet lock or by push-pull coupling. See figure 3–1 for illustrations of AN type connectors, and figure 3–2 for illustrations of miniature MS connectors.

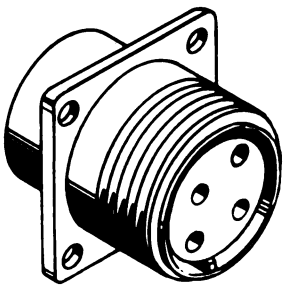
3–7. The receptacle is usually the "fixed" part of the connector, and is attached to a wall, bulkhead or equipment case. The plug is the removable part of the connector and includes the coupling ring. When the two parts are joined by the coupling device, the electric circuit is made by pin-and-socket contacts inside the connector. The "live" or "hot" side of the circuit usually has socket (female) contacts. Either the plug or the receiptacle may contain the "live" parts of the circuit. The contacts are held in place and insulated from each other and from the shell by a dielectric insert. Insert and contacts are housed in a metal shell. See figure 3–3 for the exploded view of a typical plug and figure 3–4 for the exploded view of a typical receptacle.



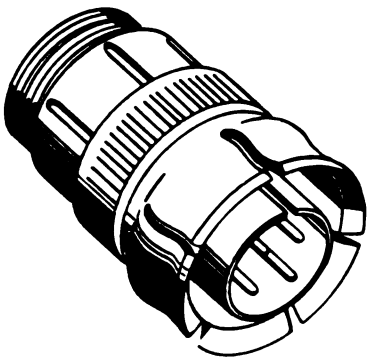
MS3100
WALL RECEPTACLE



MS3101
CABLE PLUG



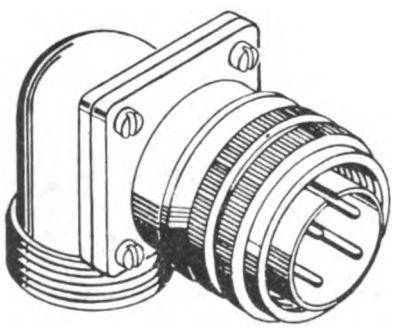
MS3102
BOX RECEPTACLE



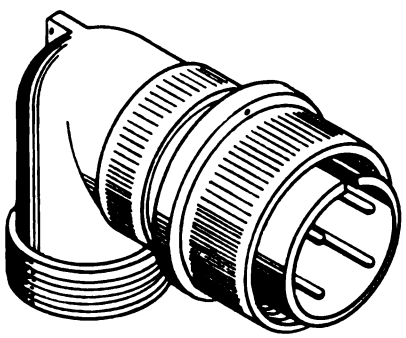
MS3107
QUICK DISCONNECT PLUG

MS3106
STRAIGHT PLUG

MS3106
STRAIGHT PLUG

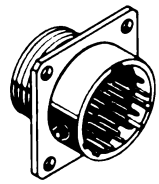


MS3108
ANGLE PLUG

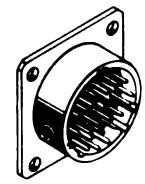


MS3108
ANGLE PLUG

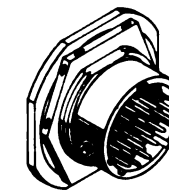
Figure 3–1. MS Connectors,– AN Type



WALL MOUNTING RECEPTACLE
SOLDER: MS3110 & MS3130
CRIMP: MS3120 & MS3140

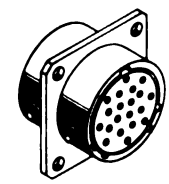


BOX MOUNTING RECEPTACLE
SOLDER: MS3112 & MS3132
CRIMP: MS3122



JAM NUT RECEPTACLE
SOLDER: MS3114 & MS3134
CRIMP: MS3124 & MS3144

STRAIGHT PLUG
SOLDER: MS3116
CRIMP: MS3126



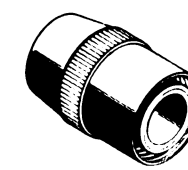
THRU-BULKHEAD RECEPTACLE
SOLDER: MS3119 & MS3139

SHORT PLUG
SOLDER: MS3137
CRIMP: MS3147

CLASS E
GROMMET SEAL

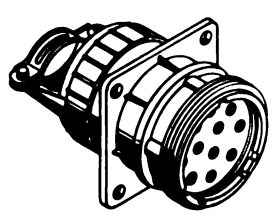
CLASS F
STRAIN RELIEF
CLAMP

CLASS P
POTTING SEAL

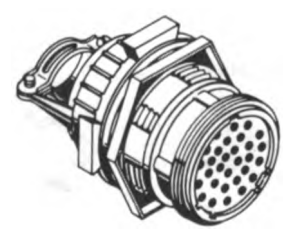


CLASS J
GLAND SEAL

a. MINIATURE CONNECTORS MIL-C-26482 - SOLDER AND CRIMP-TYPE CONTACTS



FLANGE MOUNTING RECEPTACLE
MS24264



SINGLE-HOLE MOUNTING
RECEPTACLE
MS24265

STRAIGHT PLUG
MS24266

b. MINIATURE CONNECTORS MIL-C-26500 - CRIMP-TYPE CONTACTS ONLY

Figure 3-2. MS Connectors – Miniature

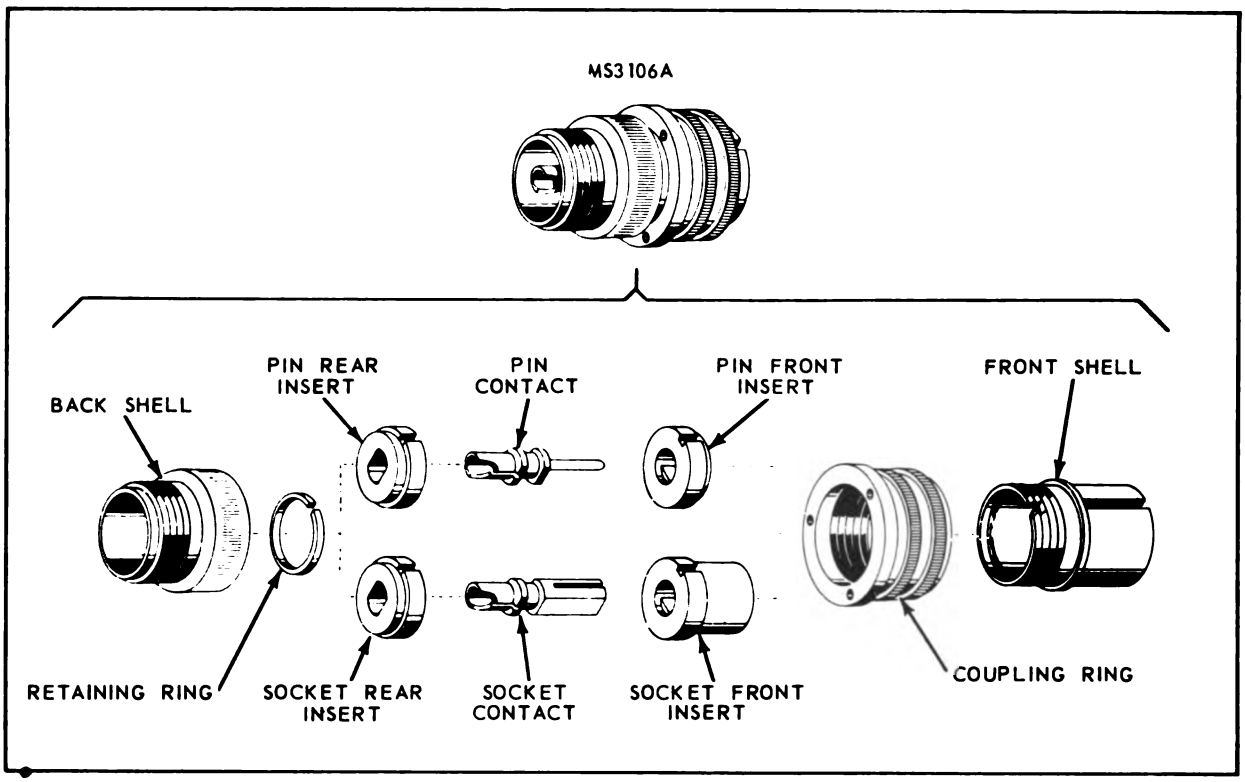


Figure 3–3. MS Connector Plug – Exploded View

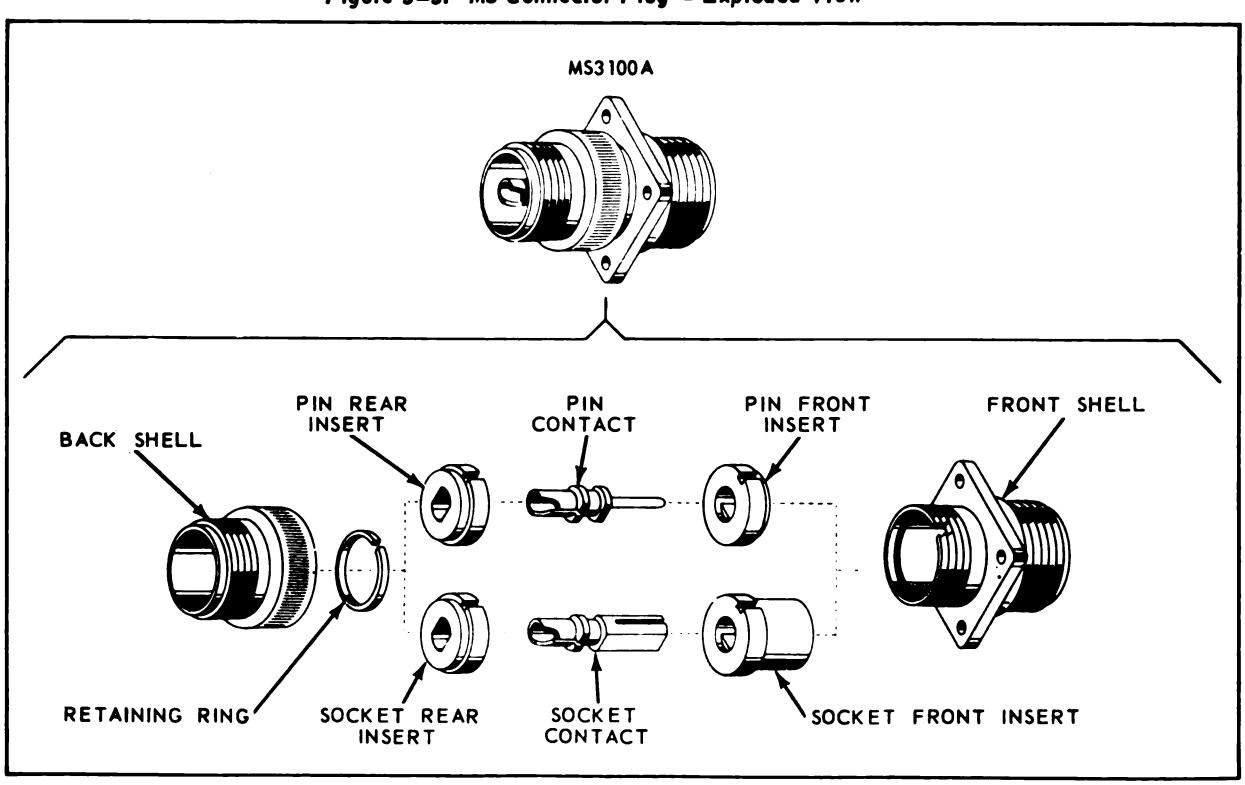


Figure 3–4. MS Connector Receptacle – Exploded View

3–8. AN-MS connectors are separated into types and classes, with manufacturer's variations in each type and class. These variations are in the method of meeting specification requirements, and in appearance. The variations are minor, and do not affect the ability to mate plugs and receptacles made by different manufacturers. There are six AN types of standard MS connectors as listed in table 3–1 and shown in figure 3–1. The connectors are further separated into the six classes listed in table 3–2.

TABLE 3–1

AN Types of Standard MS Connectors

MS Type	Nomenclature
MS 3100	Wall Mounting Receptacle
MS 3101	Cable Connecting Plug
MS 3102	Box Mounting Receptacle
MS 3106	Straight Plug
MS 3107	Quick Disconnect Plug
MS 3108	90 Degree Angle Plug

3–9. AIR CONNECTOR TYPES. See figure 3–1. The following six types of standard AN type connectors are used in aircraft:

MS 3100 - a receptacle with flange for mounting to wall or bulkhead. Contains front shell, insert retaining ring, insert, contacts and back shell. Connectors with resilient inserts omit the insert retaining ring. See figure 3–4 for the exploded view of a typical receptacle of this type.

MS 3101 - a plug used at the end of a wire or wire bundle where mounting is not necessary. Similar to MS 3100 except that it has no mounting flange.

MS 3102 - a receptacle with flange for mounting to a junction box or equipment case. Similar to MS 3100, except that it has no back shell.

MS 3106 - a straight plug, used at the end of a wire or wire bundle. Consists of front shell, coupling nut, insert retaining ring, insert, contacts and back shell. Connectors with resilient inserts omit the retaining ring. See figure 3–3 for exploded view of a typical plug of this type.

MS 3107 - a "quick-disconnect" plug, used where fast pull disconnection from the receptacle is necessary. It is similar to MS 3106 except that it is coupled to an MS receptacle by means of a friction ring instead of a coupling nut.

MS 3108 - a right-angle plug, used where wiring must make an abrupt change in direction as it leaves the plug.

3–10. AN - MS CONNECTOR CLASSES. There are six classes of AN - MS connectors. All have aluminum alloy shells except Class K which has a steel shell to achieve fire resistance.

Class A - general-purpose connector with solid one-piece back shell. Plugs and receptacles shown in figure 3–1 are all Class A (solid back shells).

Class B - connector with back shell split in two, lengthwise, used where it is important to be able to get at soldered connections easily. The two halves of the back shell are held together by clamping ring, or by screws. See figure 3–5 for exploded views of typical split shell MS connectors.

Class C - pressurized connector, used on walls and bulkheads of pressurized equipment. Externally it looks the same as a Class A receptacle, but the inside sealing arrangement is different. Inserts of Class C connectors are not removable. Mating the Class C receptacle to the other class plugs does not affect the sealing qualities of the Class C receptacle.

Class E - environment (moisture and vibration) resisting connector, used in areas where changes in temperature may cause condensation, or where there is likely to be vibration. Class E connectors have a sealing grommet in the back shell. The wires pass through tight fitting holes in the grommet and are thereby sealed against moisture. The contacts are supported in a resilient insert. For proper performance mate Class E receptacles to Class E plugs.

Class K - fireproof connector, used where it is vital that current continue to flow even though the connector may be exposed to continuous open flame. Class K connectors are longer in overall length than other classes, and have a shell made of steel instead of aluminum alloy. Inserts of Class K connectors are of special fire-resistant material, and have crimp-type contacts instead of solder-type.

Class R - lightweight environment resisting connector similar to the Class E connector, and intended to replace it where shorter length and lighter weight are required. An O - ring is provided in the MS 3106 and MS 3108 plugs for additional sealing.

3–11. MINIATURE MS CONNECTORS. Two Military Specifications cover the miniature MS connectors most commonly used in aircraft: MIL–C–26482 and MIL–C–26–500. Connectors manufactured to the requirements of MIL–C–26482 may have contacts of either the conventional solder-type, or crimp type. MIL–C–26500 connectors have crimp-type contacts only. Connectors to both specifications have contacts in sizes 20, 16 and 12 only. The types and classes of miniature MS connectors with solder-type contacts are listed in table 3–3. Miniature MS connectors with crimp-type contacts are available in the types listed in table 3–4, and are of the environment resisting classes.

TABLE 3–2

Classes of AN type Connectors

MS Class	Application	Shell	Availability 3100	3101	3102	3106	3107	3108
A	General Purpose	Solid Aluminum Alloy	Yes	Yes	Yes	Yes	Yes	Yes
B	General Purpose	Split Aluminum Alloy	Yes	Yes	No	Yes	Yes	Yes
C	Pressurized Receptacle	Solid Aluminum Alloy	Yes	No	Yes	No	No	No
E	Environmental Resistant	Solid Aluminum Alloy with strain relief clamp	Yes	Yes	Yes	Yes	No	Yes
K	Fire and Flame Resistant	Solid Steel	Yes	No	Yes	Yes	No	Yes
R	Environmental Resistant	Solid Aluminum Alloy	Yes	Yes	Yes	Yes	No	Yes

TABLE 3–3

Types and Classes of MIL-C-26482 Miniature MS Connectors with Solder Contacts

MS Type	Nomenclature	Availability Class E	Class F	Class P	Class H	Class J
Bayonet Coupling:						
MS3110	Wall Mounting Receptacle	Yes	Yes	Yes	No	Yes
MS3112	Box Mounting Receptacle	Yes	No	Yes	Yes	No
MS3114	Rear Mounting Jam Nut Receptacle	Yes	No	Yes	Yes	No
MS3116	Straight Plug	Yes	Yes	Yes	No	Yes
MS3119	Thru-Bulkhead Mounting Receptacle	Yes	No	Yes	No	No
Push-Pull Coupling:						
MS3130	Wall Mounting Receptacle	Yes	No	Yes	No	Yes
MS3132	Box Mounting Receptacle	Yes	No	No	Yes	No
MS3134	Single-Hole Mounting Receptacle	Yes	No	Yes	Yes	Yes
MS3137	Short Plug	Yes	No	Yes	No	Yes
MS3138	Lanyard Plug	Yes	No	Yes	No	Yes
MS3139	Thru-Bulkhead Mounting Receptacle	Yes	No	No	No	No

TABLE 3–4

Types of Miniature MS Connectors with Crimp-Contacts

MS Type	Nomenclature
1. MIL–C–26482	
Bayonet Coupling:	
MS3120	Wall Mounting Receptacle
MS3122	Box Mounting Receptacle
MS3124	Rear Mounting Jam Nut Receptacle
MS 3126	Straight Plug
Push-Pull Coupling:	
MS3140	Wall Mounting Receptacle
MS3144	Single-Hole Mounting Receptacle
MS3147	Plug
MS3148	Lanyard Plug
2. MIL–C–26500	
MS24264	Flange Mounting Receptacle
MS24265	Single Hole Mounting Receptacle
MS24266	Straight Plug

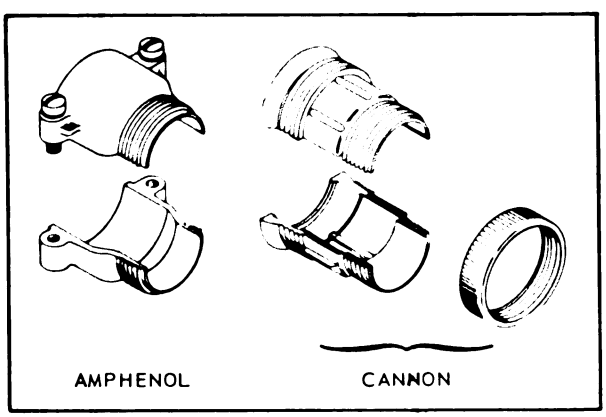


Figure 3–5. Split Back Shell Connector

3–12. MINIATURE MS CONNECTOR TYPES-SOLDER CONTACTS. The following types of miniature MS connectors with solder contacts are used in aircraft:

MS3110 - a receptacle with flange for mounting to a wall or bulkhead; is coupled by means of a bayonet lock.

MS3112 - a receptacle for mounting to junction box or equipment case similar to MS3110 except that it has no back shell; has bayonet lock coupling.

MS3114 - a rear mounting receptacle, with jam nut instead of flange; has bayonet lock coupling.

MS3116 - a straight plug for use at end of wire or wire bundle; has bayonet lock coupling.

MS3119 - a thru-bulkhead mounting receptacle; has bayonet lock coupling.

MS3130 - a receptacle similar to MS3110, except that it has push-pull (ball lock) coupling.

MS3132 - a receptacle similar to MS3112, except that it has push-pull coupling.

MS3134 - a single-hole mounting receptacle, similar to MS3114, except that it has push-pull coupling.

MS3137 - a straight plug similar to MS3116 except that it has push-pull coupling.

MS3138 - a plug with lanyard, has push-pull coupling.

MS3139 - a thru-bulkhead mounting receptacle, similar to MS3119 except that it has push-pull coupling.

3–13. MINIATURE MS CONNECTOR TYPES - CRIMP CONTACTS. These connectors are similar to the miniature connectors listed in 3–12, but have removable contacts to which wires are crimped with a standard crimping tool, instead of soldered. Connectors with crimp-type contacts are available in the following types:

MS3120 - a receptacle with flange for mounting to a wall or bulkhead; is coupled by means of a bayonet lock.

MS3122 - a receptacle for mounting to junction box or equipment case similar to MS3120 except that it has no back shell; bayonet lock coupling.

MS3124 - a rear mounting receptacle, with jam nut instead of flange; bayonet lock coupling.

MS3126 - a straight plug for use at end of wire or wire bundle; bayonet lock coupling.

MS3140 - a flange-mounting receptacle, similar to MS-3120 except that it has push-pull coupling.

MS3144 - a single-hole-mounting receptacle, similar to MS3124 except that it has push-pull coupling.

MS3147 - a plug for use at end of wire or wire bundle; push-pull coupling.

MS3148 - a plug with lanyard; push-pull coupling.

MS24264 - a receptacle with flange for mounting to a wall or bulkhead.

MS24265 - a receptacle with jam nut for panel mounting.

MS24266 - a straight plug used at the end of a wire or a wire bundle.

3–14. MINIATURE MS CONNECTOR CLASSES. There are five classes of miniature MS connectors with solder-type contacts. These are:

Class E - an environment (moisture and vibration) resisting connector, moisture-proofed by means of a wire grommet seal and clamping nut.

Class F - an environment resisting connector, similar to Class E, with addition of a strain relief clamp.

Class H - hermetic sealed receptacle which has a glass insert fused to the contacts and the shell.

Class J - a connector incorporating a gland seal for sealing a jacketed cable.

Class P - connectors supplied with a plastic potting mold, so that the connectors may be sealed by the application of a potting compound.

3–15. MS CONNECTOR MARKING. Each MS connector is marked on the shell or coupling ring with a code of letters and numbers giving all the information necessary to identify the connector. See figure 3–6. A typical code is as follows:

MS3114E12-10PW

MS Number	Shell Class	Insert Size	Insert Arrangement	Insert Style	Insert Position

a. The letters "MS" indicate that the connector has been made according to Government Standards.

b. Numbers such as 3114 indicate type of shell, and whether plug or receptacle. (Refer to 3–12)

c. Class letter indicates design of shell, and for what purpose connector is normally used. (Refer to 3–14)

d. Numbers following class letter indicate shell size by outside diameter of mating part of receptacle in one-sixteenth inch increments, or by the diameter of the coupling thread in sixteenths of an inch. For example size 12 has an outside diameter or a coupling thread of 3/4 inches.

Note

MIL–C–26500 connectors have an additional letter to indicate type of coupling between the shell size and insert arrangement code numbers. These letters are "T" for thread coupling, "B" for bayonet coupling and "Q" for push-pull coupling. For example: MS-24264R18B30P6, where B indicates type of coupling.

e. Numbers following hyphen indicate insert arrangement. This number does not indicate the number of contacts. Military Standard drawings cover contact arrangements approved for service use. See figures 3–7, 3–8 and 3–9 for illustrations of insert arrangements.

f. First letter following number indicates style of contact.

g. Second letter indicates alternate insert position. Insert position letters W, X, Y or Z, indicate that the connector insert has been rotated with respect to the shell a specified number of degrees from the normal position. Alternate positions are specified to prevent mismating when connectors of identical size and contact arrangement are installed adjacent to each other. These alternate positions are shown on governing military standard drawings. If no letter appears the insert is in the normal position. On connectors with multiple keyways the degree of rotation is measured from the widest keyway. See figure 3–10 for typical alternate position arrangements.

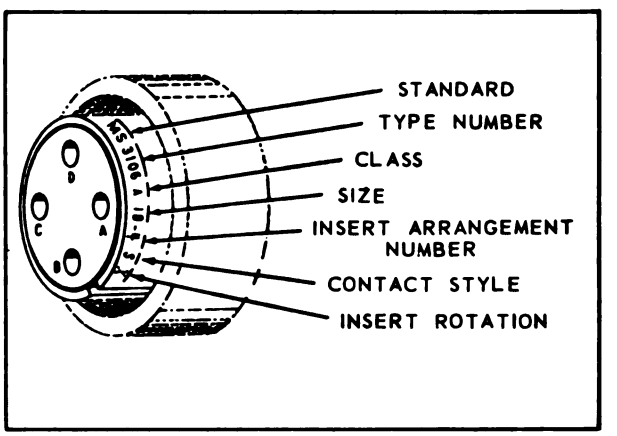


Figure 3–6. MS Connector Marking

Note

Alternate insert positions on MIL–C–265100 connectors are indicated by numbers 6, 7, 8, 9 and 10 instead of by letters.

Note

AN-MS connectors MS3100 through MS3108 with socket contacts, have the letter "C" stamped on the connector after the code identification marking, indicating that the required prod damage test has been met.

3–16. MS CONNECTOR CONTACTS. There are two kinds of contacts found in MS connectors: solder type, and crimp type. Crimp type contacts are removable. Contact sizes are related to AN wire sizes, but not all wire sizes have corresponding contacts. Contacts accommodate a range of wire sizes as shown in table 3–5. It is sometimes necessary to use a wire larger than that included in the indicated range. Special instructions are given for this in 3–101 and 3–102.

CAUTION

Use only contacts designed for use with the connector. When replacing contacts, make sure that replacement contact is identical with contact being replaced.

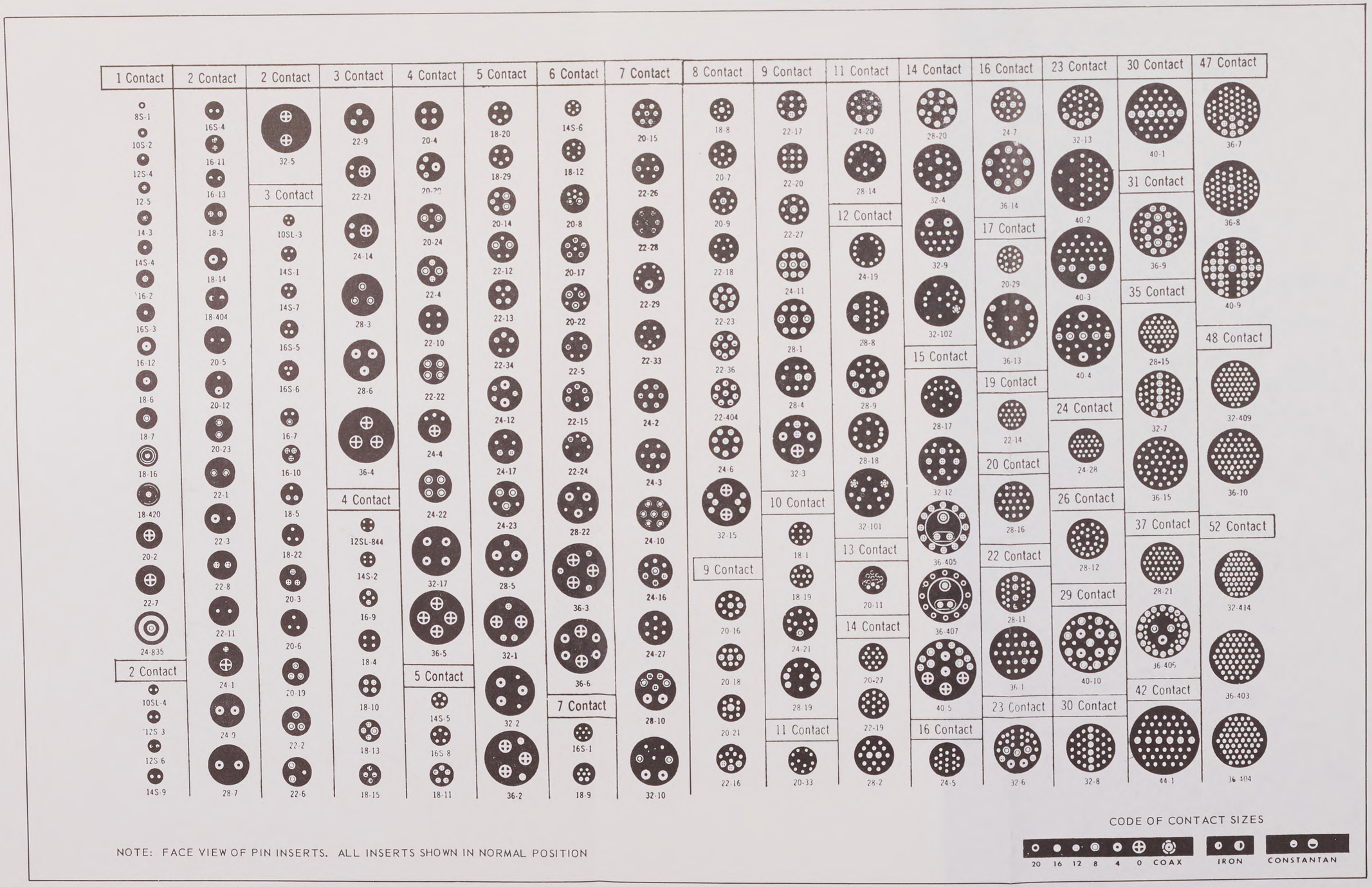
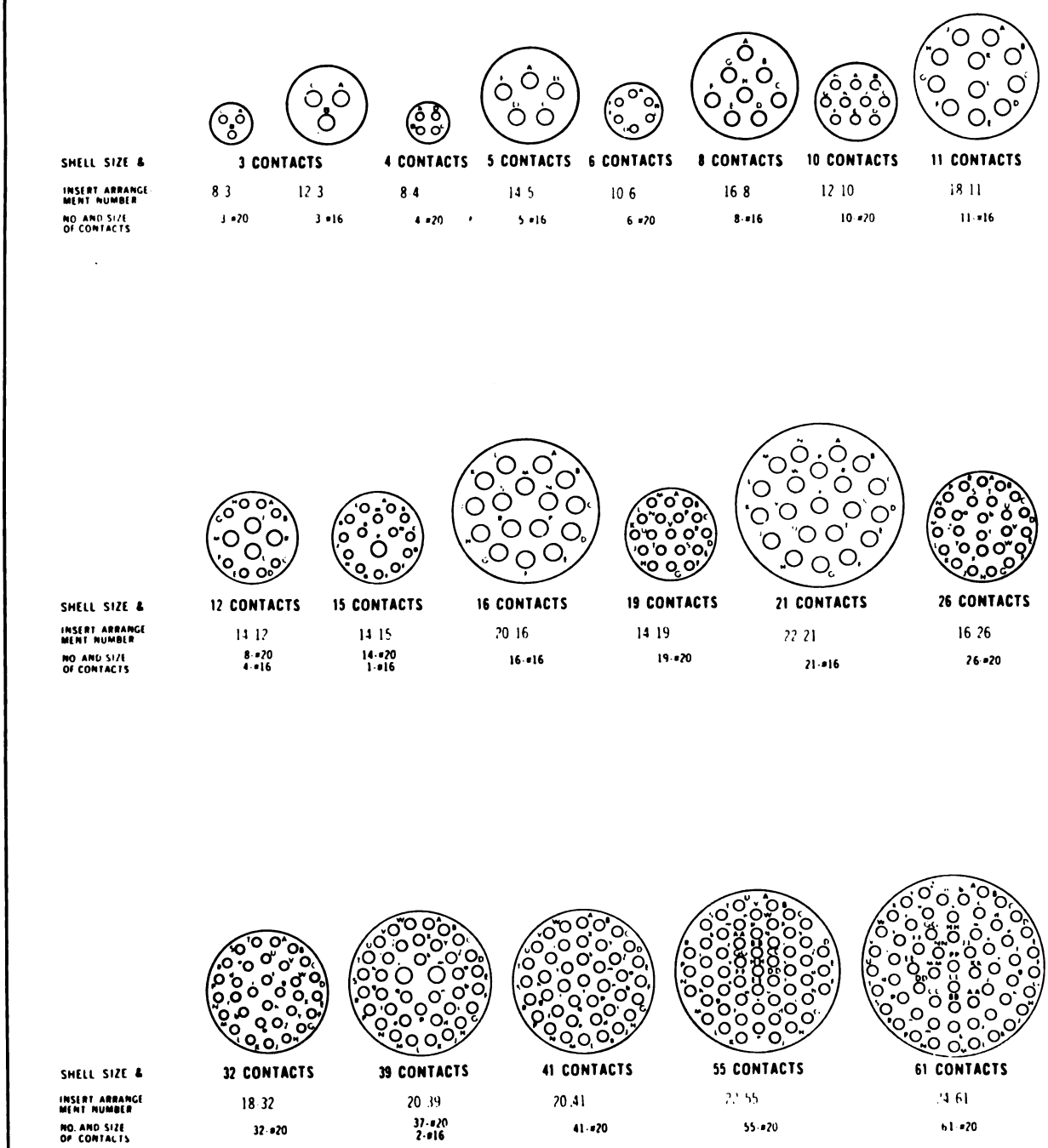


Figure 3–7. Insert Arrangements – AN Type Connectors, MIL–C–5015

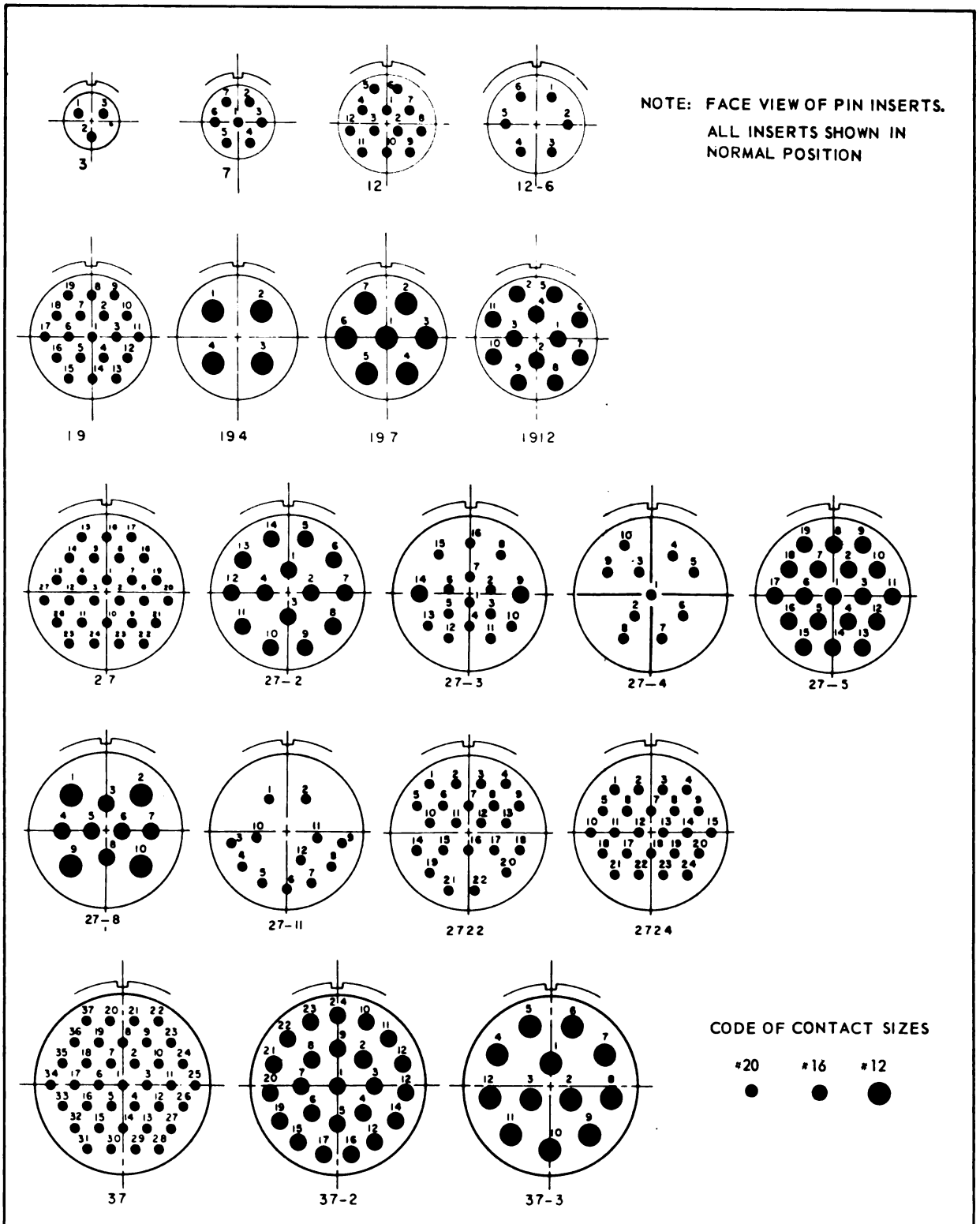
* U.S. GOVERNMENT PRINTING OFFICE: 1972-453-489/607



NOTE: FACE VIEW OF PIN INSERTS. ALL INSERTS SHOWN IN NORMAL POSITION

a. INSERT ARRANGEMENTS FOR MIL-C26482 CONNECTORS WITH BAYONET COUPLING ENGAGEMENT

Figure 3–8. Insert Arrangements – MS Miniature Connectors, MIL–C–26482 (Part I)



b. INSERT ARRANGEMENTS FOR MIL-C-26482 CONNECTORS WITH PUSH-PULL ENGAGEMENT

Figure 3-8. Insert Arrangements – MS Miniature Connectors, MIL-C-26482 (Part 2)

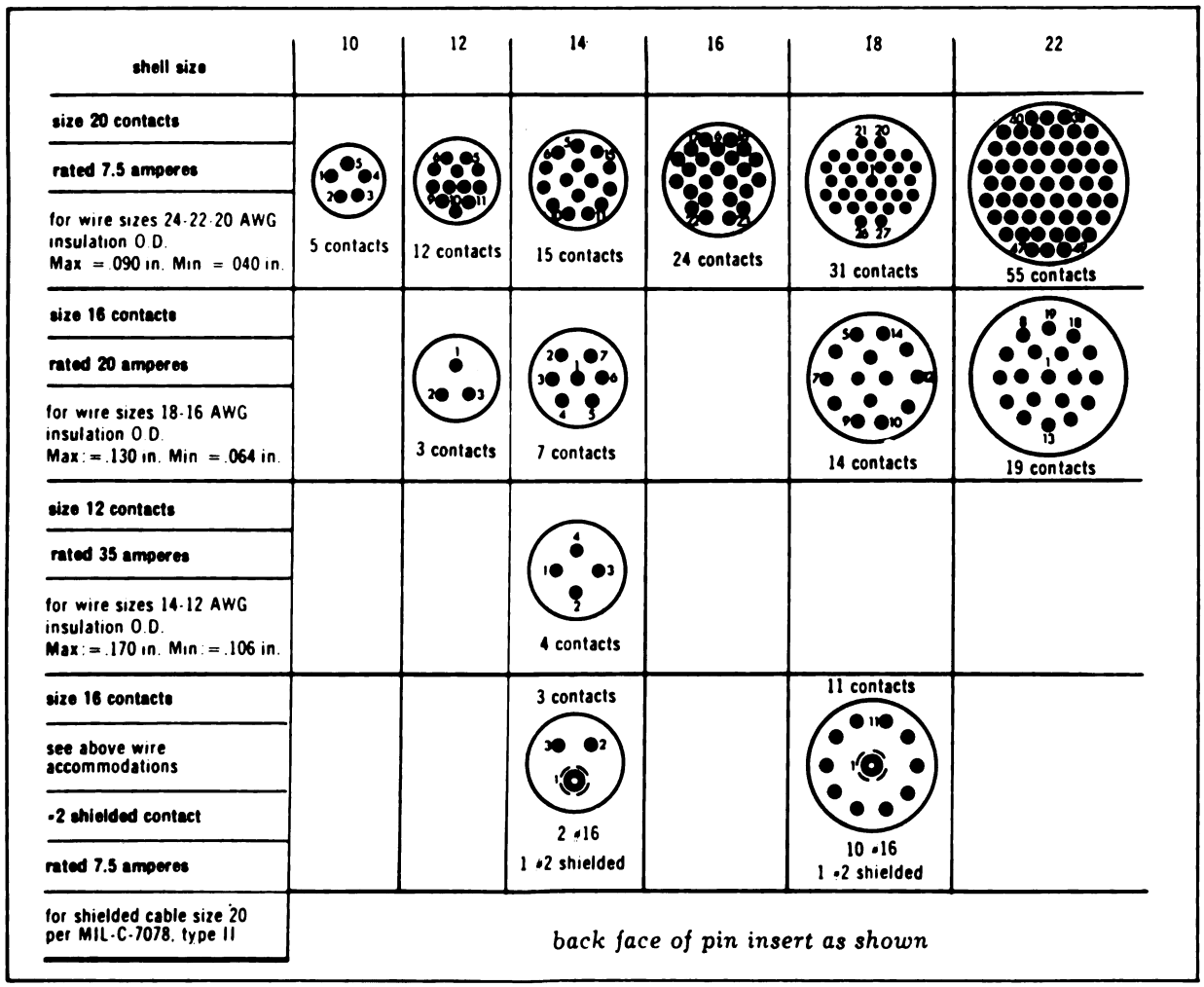


Figure 3–9. Insert Arrangements – MS Miniature Connectors, MIL–C–26500

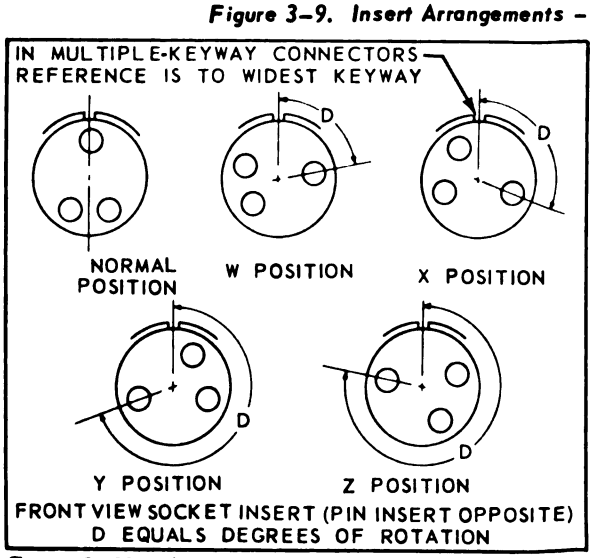


Figure 3–10. Alternate Positions of Connector Inserts

TABLE 3–5

Contacts and Their Wire Size Range

Contact Size	Wire Size Range
*20	*24-20
*16	*22-16
*12	*14-12
8	10-8
4	6-4
0	2-0

*Available in crimp type connectors

3–17. MS CONNECTOR CABLE CLAMPS. Connector cable clamps are used at the back end of MS connectors, except potted connectors, to support wiring, and to prevent twisting or pulling on soldered connections. There are three types of MS cable clamps as shown in figure 3–11. These are as follows:

a. MS3057 - consists of a clamp body, two washers, and a clamp saddle held on the clamp body by two screws and lockwashers.

b. MS3057A - consists of a clamp body and two saddles held on by screws and lockwashers. Used with AN3420 telescoping bushing.

c. MS3057B - one piece clamp with no separate cap or saddles. Used with AN3420A bushings.

3–18. MANUFACTURERS VARIATIONS IN MS CONNECTORS. (See figure 3–12) Standard AN-MS plugs and receptacles made to the requirements of a Military Specification may show differences in appearance between one manufacturer and another. Also minor changes in disassembly and installation instructions may be required. The text and illustrations to follow will show differences in detail.

3–19. MS POTTING CONNECTORS. These connectors are used only where potting is required. They are similar to other standard types, except that they have a shorter body shell and include a potting boot. MS potting connectors are available in the following types: (See figure 3–13).

MS 3103 - a receptacle with flange for mounting to a wall or bulkhead.

MS 25183 - a straight plug used at the end of a wire or wire bundle.

MS 25183A - similar to MS 25183, with the addition of a grounding screw.

3–20. SPECIAL PURPOSE CONNECTORS. In addition to connectors with MS numbers, there are some special connectors commonly used in aircraft:

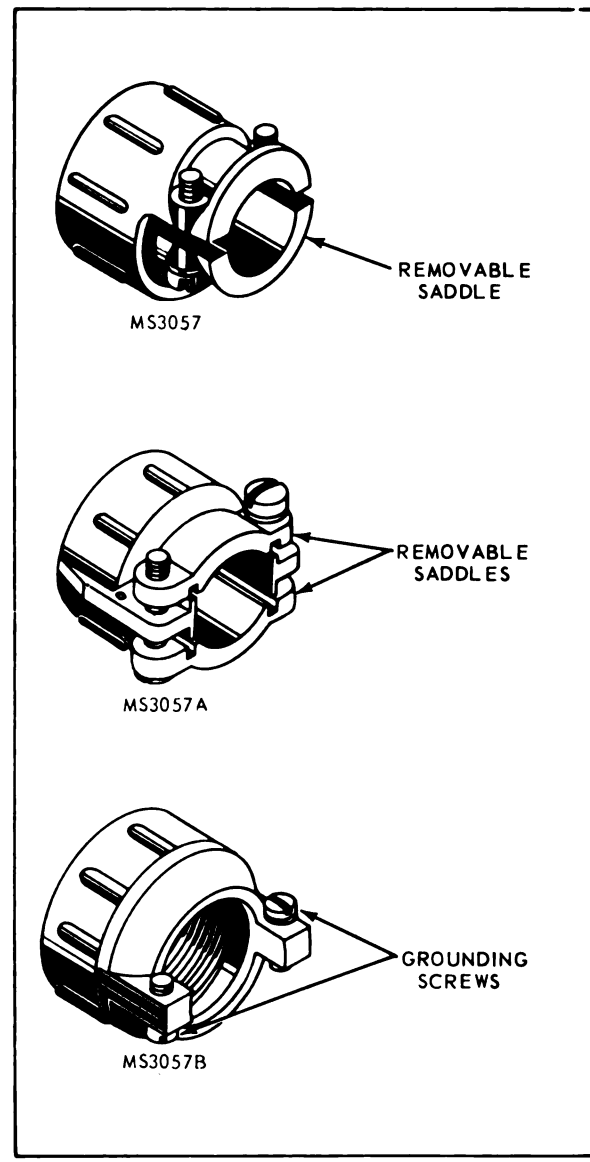


Figure 3–11. MS3057 Connector Cable Clamp Types

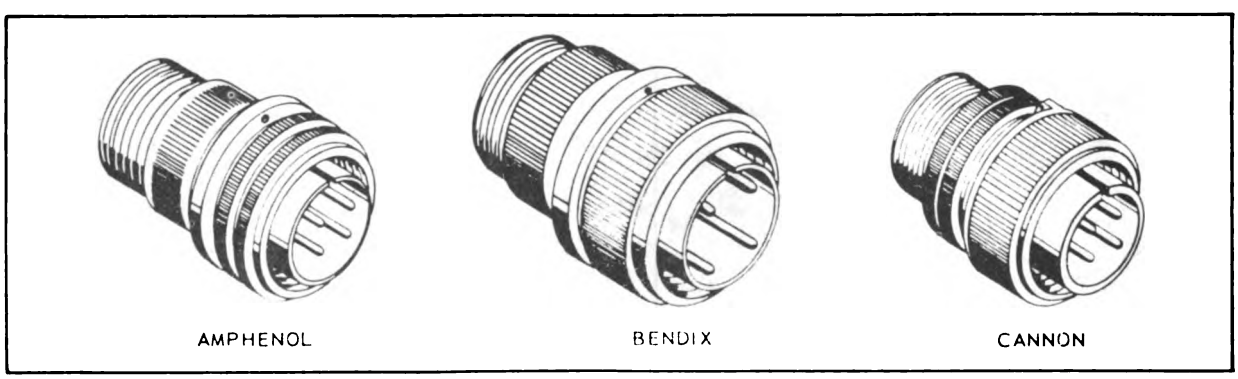


Figure 3–12. Manufacturer's Variations in AN-MS Connectors

a. Connectors with crimp-type contacts (Amphenol #69 series, Cannon Ex-A Series and Bendix 10-214000 series standard size; Bendix CE series miniature). Connectors similar to MS standard or MS miniature solder type connectors, but with removable crimp-type contacts, are available for use where the added reliability of a crimped connection, and the greater ease of circuit change and maintenance provided by removable contacts is desirable. These special connectors will mate with the corresponding MS connectors, and are similar in appearance.

b. Subminiature connectors (Cannon US series). These are wire connecting types only; they have no mounting flanges, but can be mounted with nut and lockwasher. They are used on instruments, switches, relays, transformers, amplifiers, etc. See figure 3–14.

c. Rectangular shell connectors (Bendix SR; Cannon DPD). See figure 3–15. These connectors are flanged for panel or equipment mounting. They consist of an aluminum alloy shell, rigid or resilient insert, and pin or socket contact. They are usually potted to protect connections against moisture at the back of the connector. The mating faces are not moisture sealed.

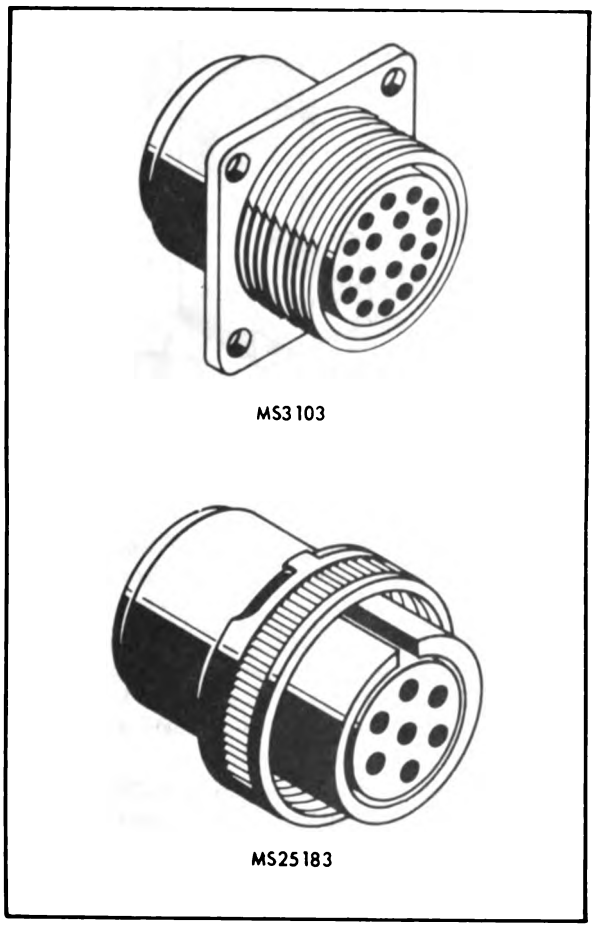


Figure 3–13. Potting Connectors

d. Miniature rectangular connectors (Winchester A and SA series). These are rack-and-panel connectors, having a one piece molded body and pin and socket contacts. These connectors are available with either solder cup contacts or taper pin receptacles. See figure 3–16.

e. Environment-resisting fireproof connectors (Cannon KE series). These connectors are similar to the MS-K series, with the addition of a moisture-resisting seal. They will mate with MS-K plugs or receptacles, but retain the moisture sealing feature only when mated with corresponding KE series plugs or receptacles.

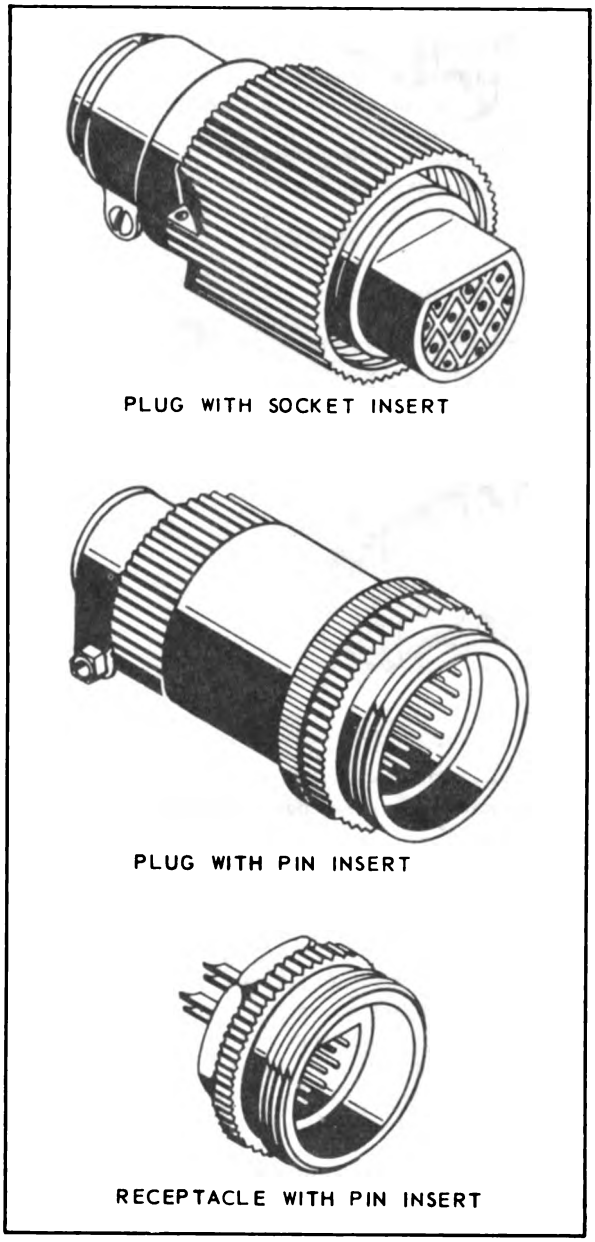


Figure 3–14. Subminiature Connectors

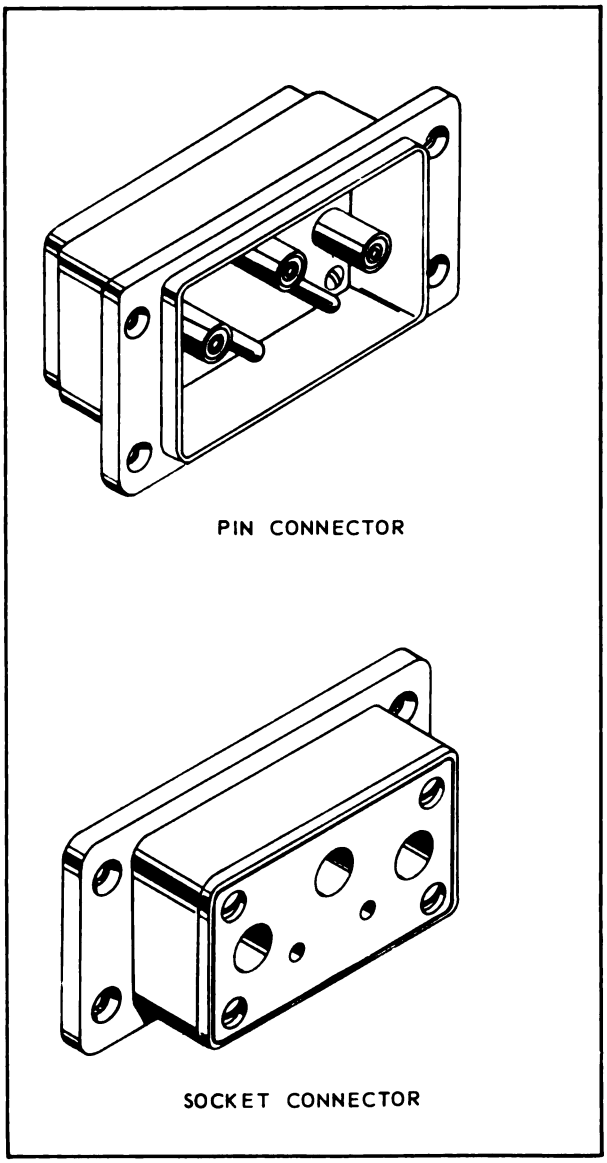


Figure 3–15. Rectangular Shell Connectors

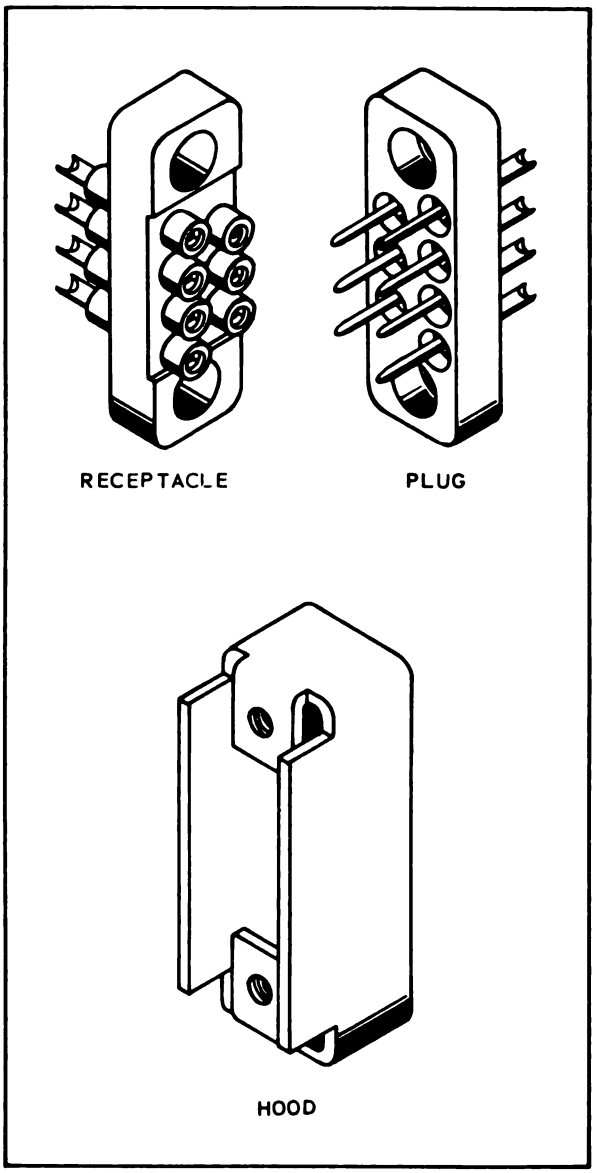


Figure 3–16. Miniature Rectangular Connectors

3–21. DISASSEMBLY OF CONNECTORS.

3–22. GENERAL. Solder type contacts size 8 and smaller are usually not removed for assembly purposes. Large solder contacts (size 4 and larger) are removed from connectors with hard inserts to protect the insert against the greater amount of heat necessary to properly solder wires to the larger contacts. Large solder contacts may be removed from connectors with resilient inserts provided the connector is not a pressurized assembly with the contacts bonded into the insert. Crimp-type contacts are removed to enable the contact and wire assembly to be inserted into a crimping tool. Detailed instructions for disassembly of each MS connector variation are given in the following paragraphs. Because of the differences in connectors made by the manufacturers, the detailed disassembly instructions are given separately for each manufacturer where necessary.

3–23. REMOVAL OF BACK SHELLS. Remove back shells, if present, from all connectors before attaching wires. Solid back shells of Classes A, C and K are removed by unscrewing from the front shell as shown in figure 3–17.

Split back shells of Class B connectors are held together either by an assembly ring or by captive screws. See figure 3–18 for details of disassembly.

Class E and Class R connectors require a special disassembly technique which is described in later paragraphs.

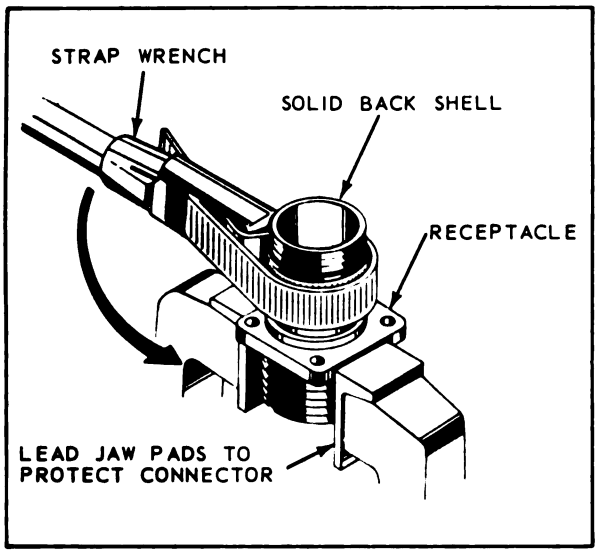


Figure 3–17. Removal of Solid Back Shell

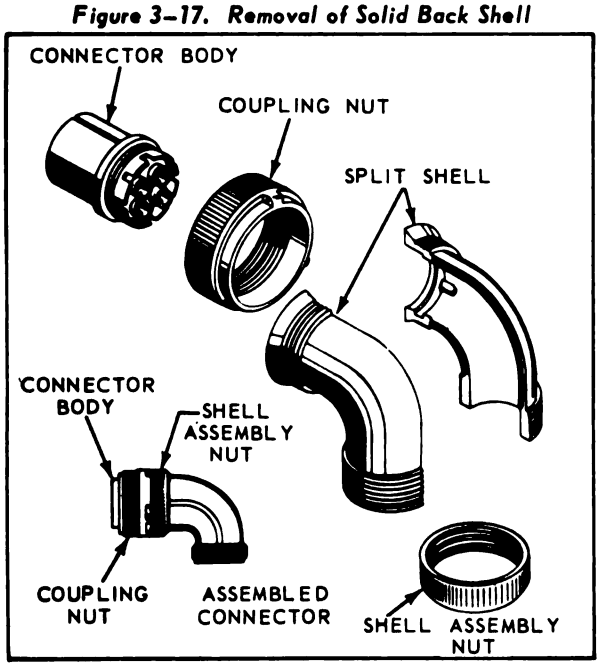


Figure 3–18. Removal of Cannon Split Back Shell

3–24. REMOVAL OF CONTACTS. Solder-type contacts sizes 4 and 0 are removed before soldering provided they are not bonded in the connector (refer to 3–22). Amphenol Class C pin contacts sizes 4 and 0 are threaded into the insert and can be removed safely. Size 8 contacts (if not bonded in the connector), may be removed if close spacing makes soldering difficult.

CAUTION

Avoid removing contacts from Class C, Class E and Class R connectors. Never remove inserts from Class C, E and R connectors.

Solderless contacts such as supplied in Class K must be removed in order to crimp wire into contacts. Contacts are removed by the following procedures:

a. Cannon spring clip contacts (see figure 3–19) are removed by prying off the clip with a small screwdriver or scriber. Rotate contact 90° and lift out.

b. Amphenol two piece inserts have contacts which are held in place by the insert halves. See figures 3–20 and 3–21. Pry out retaining ring which holds insert in place with small screw driver. Remove inserts and separate them. This will free contacts.

c. Some Bendix and Cannon connectors have resilient inserts. Contacts are removed from these resilient inserts by pushing against the solder cup end with a round phenolic rod a little smaller in diameter than the solder cup. An arbor press, as shown in figure 3–22 is helpful in removing large size contacts.

CAUTION

Never use pliers to remove contacts. This will damage the contacts.

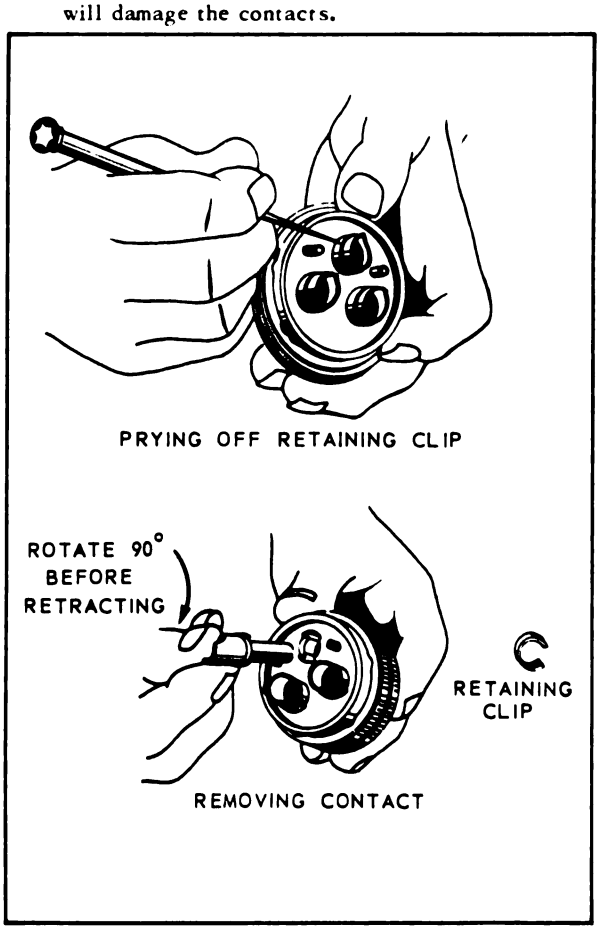


Figure 3–19. Removal of Cannon Clip Held Contacts

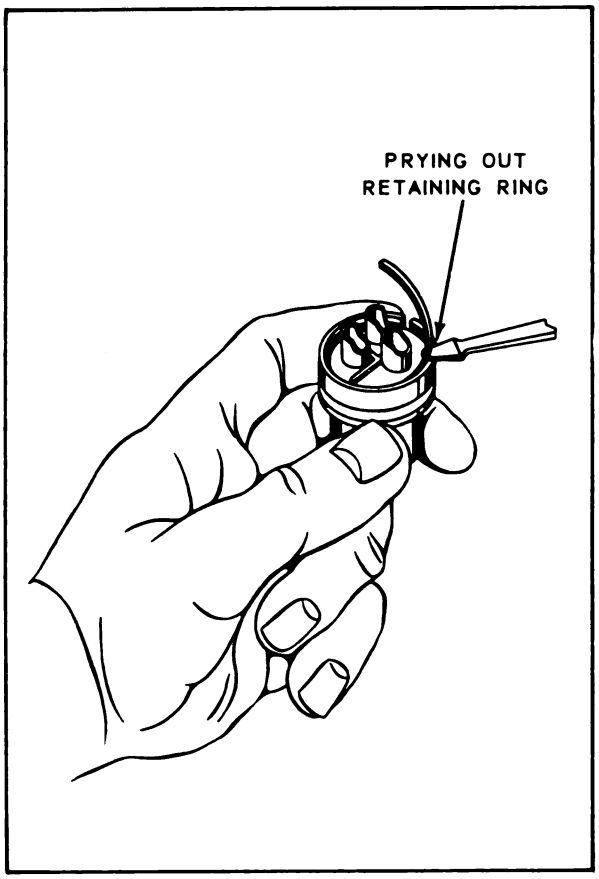


Figure 3–20. Removal of Amphenol Insert Assembly

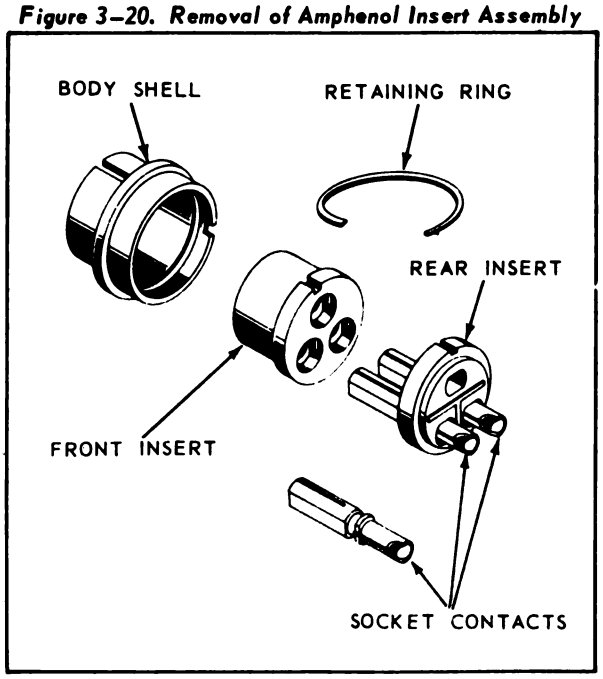


Figure 3–21. Amphenol Contact and Insert Assembly – Exploded View

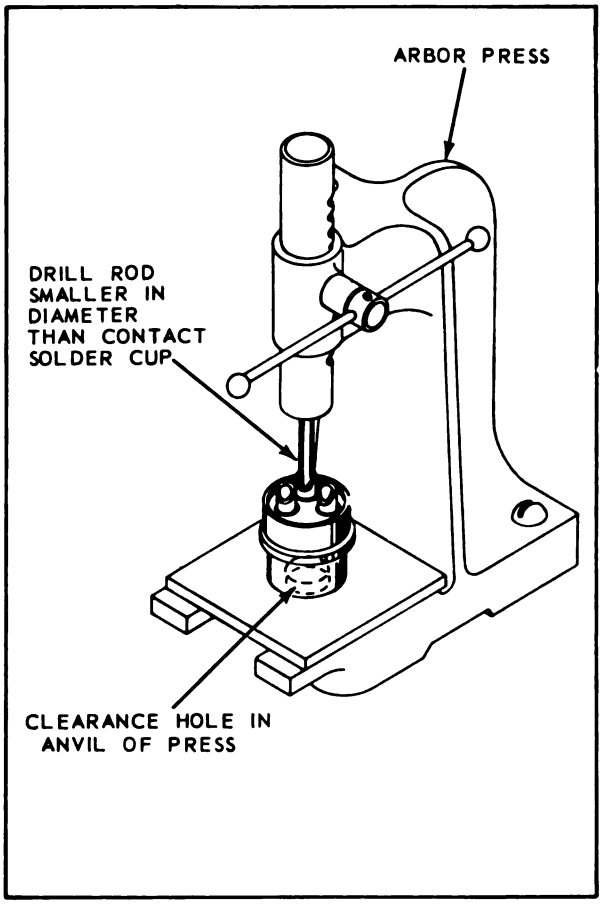


Figure 3–22. Removal of Solder Contacts from Resilient Insert

3–25. DISASSEMBLY INSTRUCTIONS FOR AN-MS CLASS E CONNECTORS. Class E (environment-resisting) connectors are made in two forms. Those made by Bendix have a separate cable clamp similar to MS 3057B. Those made by Cannon use a cable clamp which is part of the back shell and similar to MS 3057A (see figure 3–23).

3–26. Disassembly of a Bendix Class E connector is accomplished as follows:

a. Unscrew cable clamp from back shell, using strap wrench or padded jaw connector pliers if necessary.

b. Remove tapered grommet compression sleeve and grommet from back shell.

c. Unscrew back shell from body assembly using strap wrench or padded jaw pliers if necessary.

d. Remove contacts size 8 and larger as described in 3–24.

Note

Avoid removing contacts from Class E receptacles.

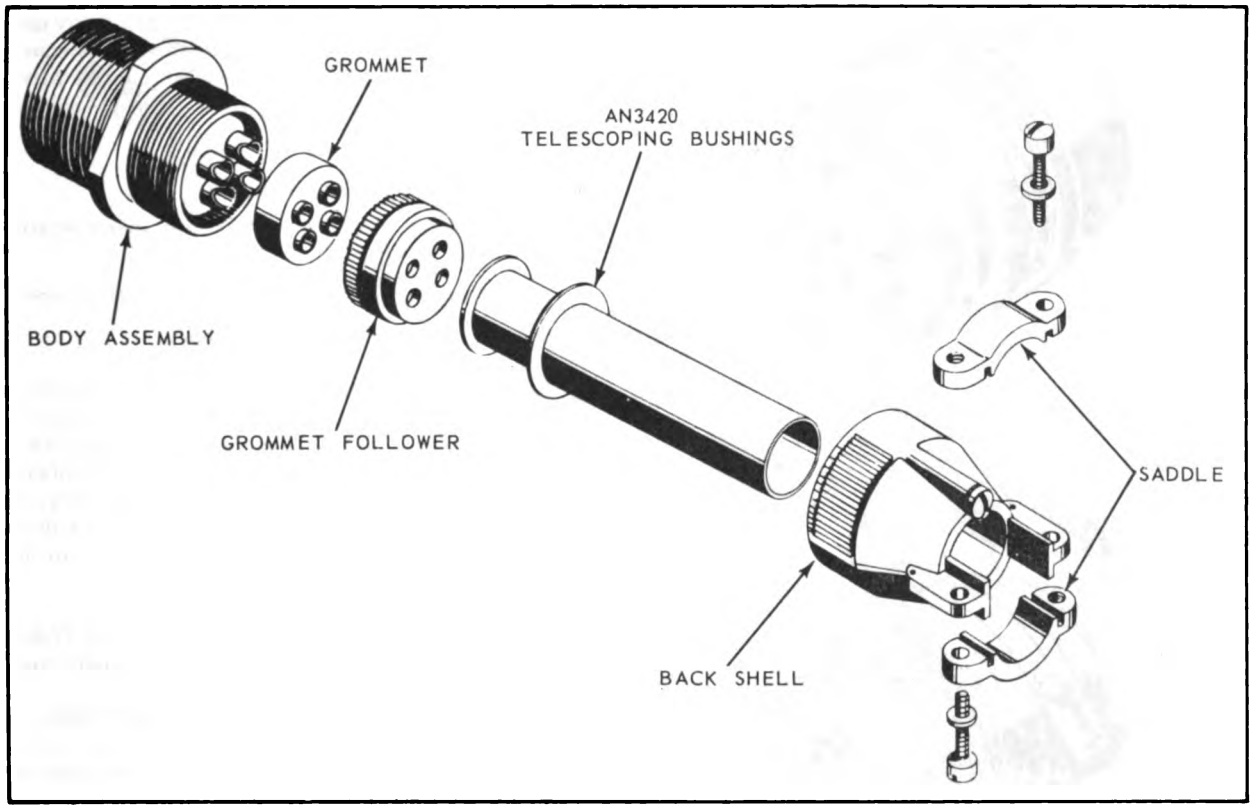


Figure 3–23. Class E Connector – Cannon – Exploded View

3–27. Disassemble Class E connectors made by Cannon as follows:

a. Remove cable clamp saddle by removing two screws. Unscrew cable clamp if MS 3108E.

b. Unscrew back shell from body assembly, using strap wrench if necessary.

c. Remove AN3420 telescoping bushing(s).

d. Remove grommet follower (grommet retainer) and grommet.

e. Remove contacts size 8 and larger as described in 3–24.

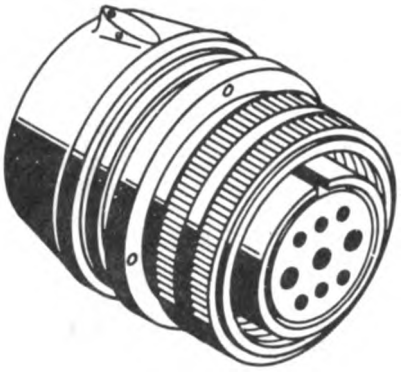
CAUTION

Do not remove inserts of moisture-proof connectors. Removal will destroy the moisture-proofing. Do not remove contacts smaller than size 8 except for replacement.

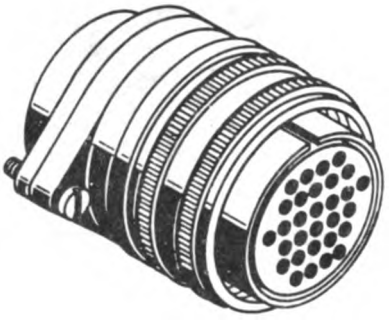
3–28. MS CLASS R CONNECTOR DISASSEMBLY. These new lightweight environment-resisting connectors differ in appearance from Class E connectors. See figure 3–24. Class R connectors have no separate cable clamp. A grommet, grommet compression nut and ring are preassembled as a single unit, which is disengaged from the shell assembly before wiring contacts. The cable clamp has been replaced with a back nut and compression sleeve. The nut backs the grommet away from the contacts when removed. To disassemble, remove compression sleeve and grommet and unscrew back nut from body assembly. See figure 3–25. The cable clamp has been retained on the MS3108R angle plug which is identical with MS3108E except for improved sealing. Otherwise disassembly instructions for Class R connectors are the same as for the Class E connectors. To effect a satisfactory seal, the grommet must seat against the rear face of the insert.

3–29. DISASSEMBLY OF MINIATURE MS CONNECTORS WITH SOLDER TYPE CONTACTS. Miniature MS environment-resisting connectors, Class E, are disassembled as described in 3–25, except that there is no back shell, and contacts are not removed. Class P potting connectors are disassembled by removing the plastic potting mold and retaining ring. Class H hermetically sealed connectors are not disassembled.

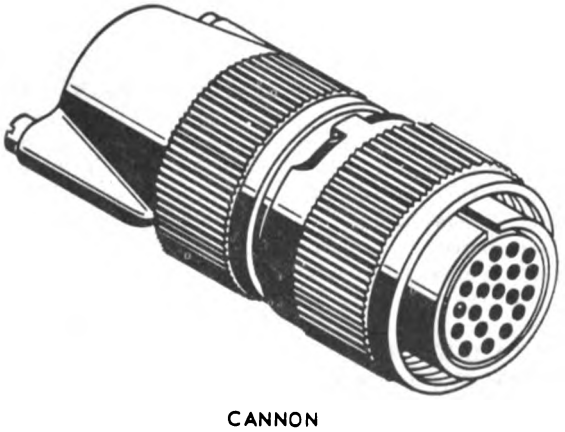
3–30. INSTRUCTIONS FOR MS CONNECTORS WITH REMOVABLE CRIMP-TYPE CONTACTS. The contacts for this type of connector are usually packaged separately, so very little disassembly of the connector is necessary. For Class E or F connectors, remove the grommet compression nut and sleeve. The grommet is bonded to the insert and is *not* removable. On Class P connectors, remove the potting mold and retaining ring. If the contacts have been assembled into the connector, remove them as described in 3–91.



AMPHENOL



BENDIX



CANNON

Figure 3–24. Class R Connectors

3–31. DISASSEMBLY INSTRUCTIONS FOR CANNON DPD CONNECTORS. Cannon DPD connectors are used in installations where it is necessary to simultaneously disconnect coaxial cables and general purpose wires. DPD connectors are disassembled as follows: (See figure 3–26)

a. Remove four self-locking nuts.

b. Lift away coaxial contact and insert retainer clips.

c. Pull out coaxial contacts from rear of insert.

d. Remove insert from front of body.

3–32. SUBMINIATURE CONNECTOR DISASSEMBLY. (Cannon US series) Contacts are not removed from this type of connector. The connector is disassembled by removing the keeper, coupling nut, two-piece plastic sleeve and ferrule; these pieces are installed over the wire bundle in that order before soldering wires to the contacts. See figure 3–27 for an exploded view of this connector.

3–33. MINIATURE RECTANGULAR CONNECTORS. No disassembly is necessary for these connectors.

3–34. ASSEMBLY OF WIRES TO CONNECTORS.

3–35. WIRE TYPES. Five types of wire and cable are normally fastened to connectors. These are:

a. Tin-coated copper wire (MIL–W–5086)

b. Silver-coated copper wire (MIL–W–7139, MIL–W–8777, MIL–W–16878, MIL–W–22759)

c. Nickel-plated copper wire (MIL–W–22759, MIL–C–25038 and MIL–W–27300)

d. Coaxial cable (MIL–C–17)

e. Thermocouple wire (MIL–W–5845, MIL–W–5846)

The choice of wire is controlled by the installation requirements and is indicated on the engineering drawing and parts lists.

3–36. SOLDERS. Solders and other fastening means are matched to the wire type and to the installation as follows:

a. Soft solder - 60/40 tin-lead (Federal Specification QQ-S-571, composition Sn 60) is used for tin-coated copper wire and for coaxial cable.

b. Soft solder - lead-silver (Federal Specification QQ-S-571, composition Ag 2.5 or Ag 5.5) is used for silver-coated copper wire.

c. Crimp connections are used for nickel-clad copper wire, and tin, silver or nickel coated copper wire.

d. Thermocouple wires require special procedures which are detailed in section VII.

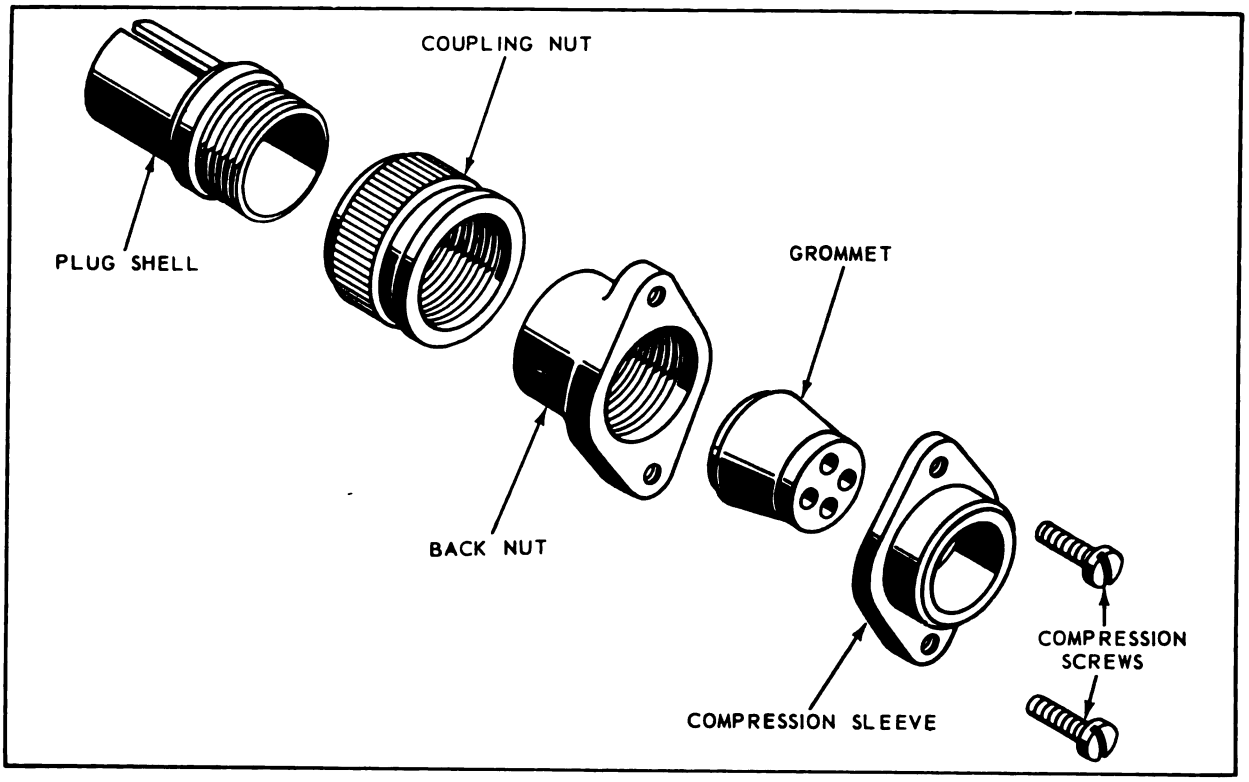


Figure 3–25. Class R Connector – Bendix – Exploded View

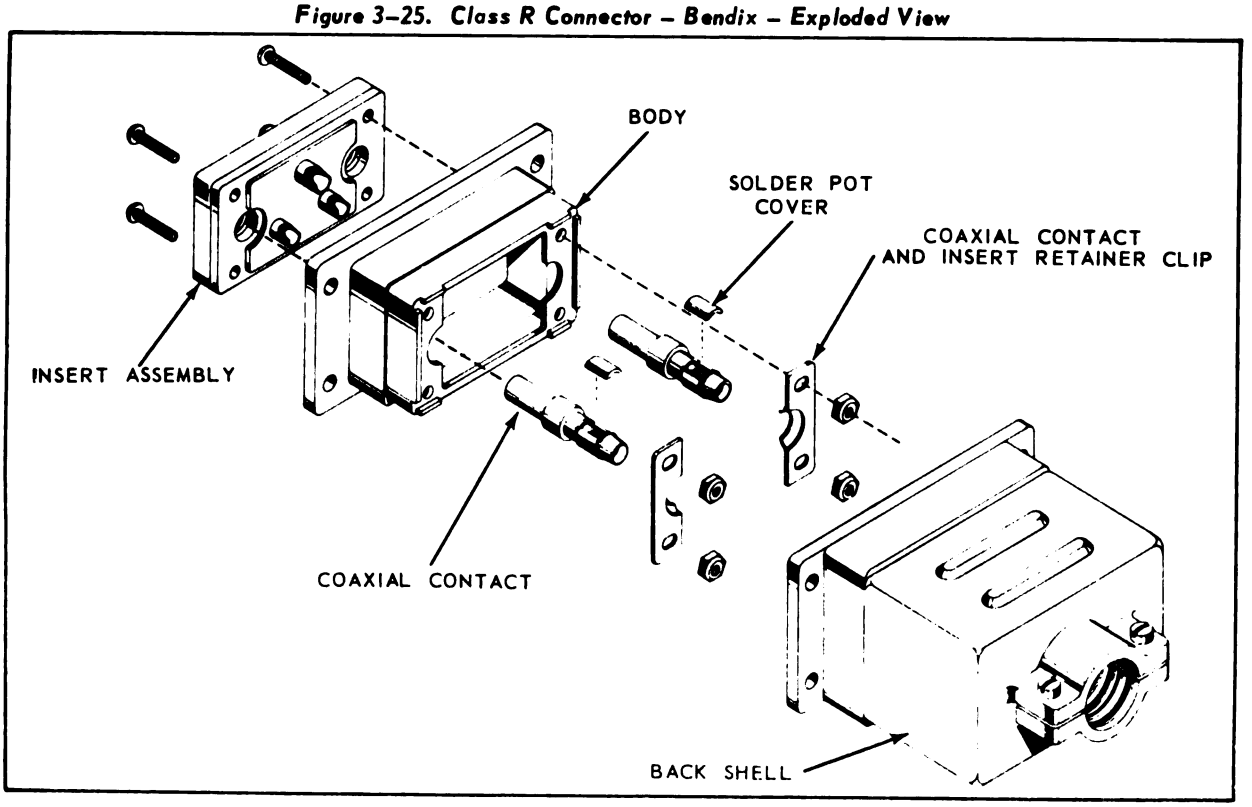


Figure 3–26. Rectangular Shell Connector – Cannon DPD – Exploded View

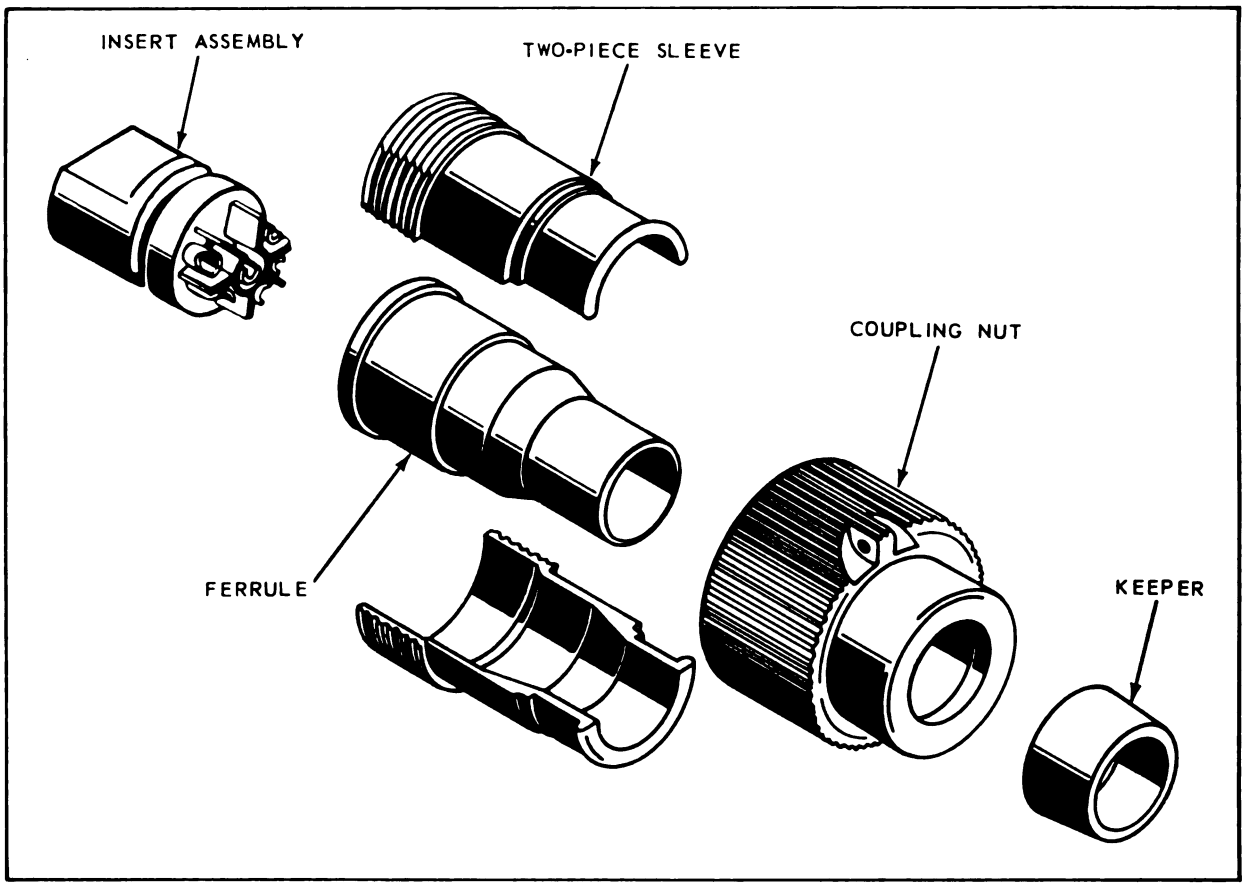


Figure 3–27. Subminiature Connector – Exploded View

3–37. CONTACTS. Contacts are supplied in two types:

a. Solder cup - for all standard AN-MS connectors, except Class K, and for miniature MS connectors listed in table 3–3.

b. Crimp-type - for MS Class K connectors, and for MS miniature connectors with removable crimp-type contacts described in 3–13.

Solder cup contacts are silver or gold plated to provide low contact resistance. Silver plated contacts have pre-tinned solder cups. Gold plated contacts are not pre-tinned because the gold prevents oxidation and is therefore always easy to solder. Crimp type contacts are gold or rhodium plated, and are not pre-tinned.

3–38. PREPARATION OF WIRES BEFORE ASSEMBLY. The preparation of wires before assembly is as follows: (See section II)

a. Cut wire to prescribed length.

b. Identify wire with proper coding.

c. Strip ends to the dimensions in tables 3–6 or 3–7 as applicable.

TABLE 3–6

Stripping Lengths For Solder Connections

Contact Size	Stripped Length (inches)
20	1/8
16	1/4
12	5/16
8	5/8
4	5/8
0	3/4

d. Tin wires which are to be soldered to contacts. Do not tin wires which are to be crimped to contacts.

3–39. INSULATING SLEEVES. Insulating sleeves are used over soldered connections to help protect the connection against vibration and to lengthen the arc-over path between contacts. Insulating sleeves are not used under the following conditions:

a. Insulating sleeves are not used when connectors are to be moisture-proofed by potting.

b. Insulating sleeves are not used in miniature MS connectors, nor in AN type Class E or Class R connectors, as the sealing grommets cover the soldered connection. Class E connectors made by Bendix need insulating sleeves, as the grommets do not cover the soldered connection. The insulating sleeve should not extend into the grommet.

TABLE 3–7

Stripping Lengths For Crimp Connections

Contact Size	Wire Size (AN)	Stripped Length (Inches)
20	20, 22 & 24	3/16
16	16, 18 & 20	1/4
12	12 & 14	5/16
8	8	9/16

Note

No. 22 wire can be crimped into No. 16 contact provided the No. 22 wire is stripped to 1/2 inches and doubled back on itself.

3–40. SELECTION OF INSULATING SLEEVES. Select insulating sleeving from the materials listed in table 3–8 to suit the temperature conditions in the area where the connector will be installed. Select the proper size from table 3–9, so that the inside diameter of the sleeving will fit snugly over the solder cup.

3–41. INSTALLATION OF INSULATING SLEEVES. Cut the sleeving into lengths, as given in table 3–9, to cover the soldered connection completely from the insert to a little over the wire insulation. See figure 3–28. Slip insulating sleeve of correct size, material and length over each prepared wire, far enough back from the stripped end to avoid heat from soldering operation (about one inch).

3–42. SOLDERING PROCEDURE. Wires are soldered to contacts in electrical connectors by means of a soldering iron, resistance heating, or a torch. Safe connections are the result of clean parts carefully soldered together. See section IX for a description of soldering methods and procedures. When soldering wires to electrical connectors, observe the following precautions:

a. Make sure that the wire and the contact are clean, and properly tinned.

b. Use a soldering iron, or other heating method, of a heat capacity sufficient for the work to be soldered. Resistance soldering is recommended for sizes 8 thru 0. A soldering iron is recommended for sizes 12 thru 20; resistance soldering may also be used.

c. Make sure that the iron has a smooth well-tinned tip. See section IX for detailed instructions on the care and maintenance of the soldering iron.

d. Keep electric resistance pliers clean and free from flux and solder splatter. Use a brass wire hand brush to clean contacting surfaces.

e. Select a soldering iron tip of a shape to provide good heat transfer. A large contact area touching the solder cup will help to produce a good connection quickly. See figure 3–29 for suitable soldering iron tips.

f. Use only rosin or rosin-alcohol as flux for soldering wires to connector contacts.

CAUTION

Do not use any corrosive flux for soldering in an electric connector.

g. Do not hold the hot iron against the solder cup longer than necessary; this will force solder up into the conductor and stiffen the wire. Stiff wires will break under vibration.

h. Avoid having solder run on the outside of solder cup or dripping to insert face. Do not move the soldered connection until the solder has hardened.

i. Solder has little mechanical strength. Do not depend on solder to keep a wire from pulling out of a contact. Use a cable clamp, grommet seal or potting to give mechanical strength.

TABLE 3–8

Insulating Sleeving Material

Temperature Range	Material	MIL Spec.
Up to 160°F	Vinyl, transparent Nylon, transparent	MIL–I–7444 or MIL–I–631
160°F-400°F	Silicone-impregnated fiberglass	MIL–I–3190
	Silicone-rubber fiberglass	MIL–I–18057
400°F-600°F	Extruded TFE	– – –
	TFE-impregnated fiberglass	– – –

TABLE 3–9

Insulating Sleeving Sizes

AN Wire Size	Insulating Sleeving Number	ID	Length (in inches)
16-14	7	.148	3/4
12	5	.186	3/4
10	3	.234	3/4
8	1	.294	1
6	0	.330	1-1/4
4	7/16	.438	1-1/4
2	1/2	.500	1-1/4
0	5/8	.625	1-1/4

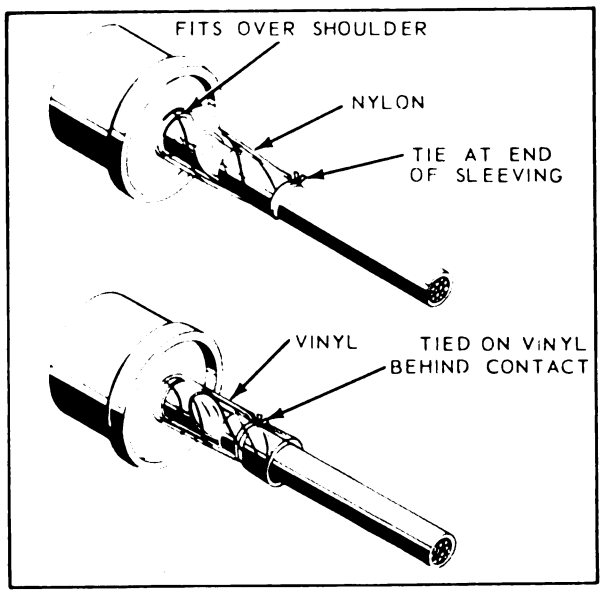


Figure 3–28. Insulating Sleeving Installed Over Solder Cup

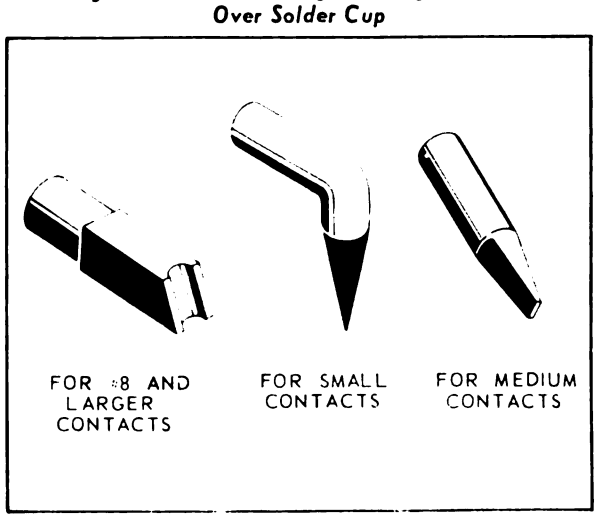


Figure 3–29. Soldering Iron Tip Shapes

3–43. ELECTRICAL RESISTANCE SOLDERING. Resistance soldering will yield excellent results for both very large and very small contacts.

a. Large contacts are soldered to wires by the use of resistance soldering pliers. See figure 3–30. The contact, removed from insert, is held in the jaws of the pliers and current is applied until the solder in the solder well has melted. Then the pre-tinned wire is inserted slowly into the solder cup while current is still being applied. After the wire is fully inserted, continue heating until the solder flows to form smooth fillet. Allow joint to cool and harden without movement.

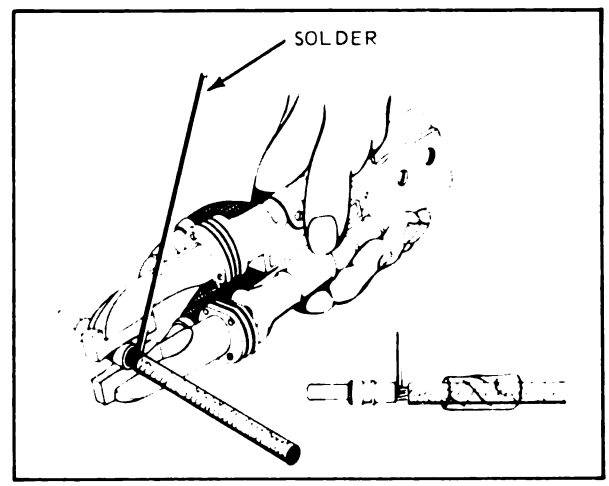


Figure 3–30. Resistance Soldering Pliers for Large Contacts

b. Small contacts are heated for soldering by use of pencil type resistance soldering tool shown in figure 3–31. The two electrodes of the tool are placed in contact with the side of the solder cup so that the heating current will pass through the wall of the cup. When the solder in the cup flows, insert the pre-tinned wire. Continue to apply heat to connection until solder flows to form smooth fillet, then stop current and allow joint to cool without movement.

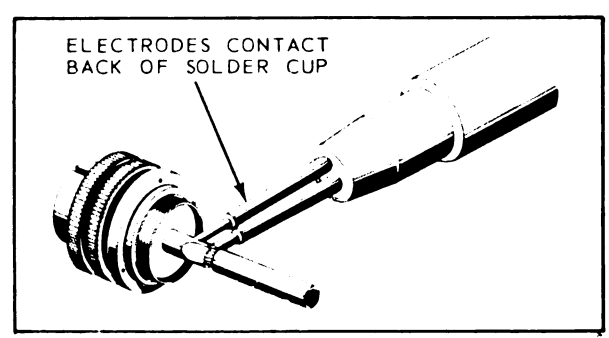


Figure 3–31. Resistance Soldering Pencil for Small Contacts

3–44. TORCH SOLDERING. A torch can be used to solder wire into a large contact which has been removed from its insert. (See figure 3–32). The contact is held in a non-metallic block to avoid heat loss, and the torch is played over the solder cup area until the solder melts.

CAUTION

Do not overheat. Excessive heat will destroy the plating and soften the contact.

When the solder in the cup has melted, insert the wire slowly into the cup and add more 60/40 rosin-core solder if necessary. Continue to heat the connection until the solder flows into a smooth fillet, then remove the flame. Allow the joint to cool without movement.

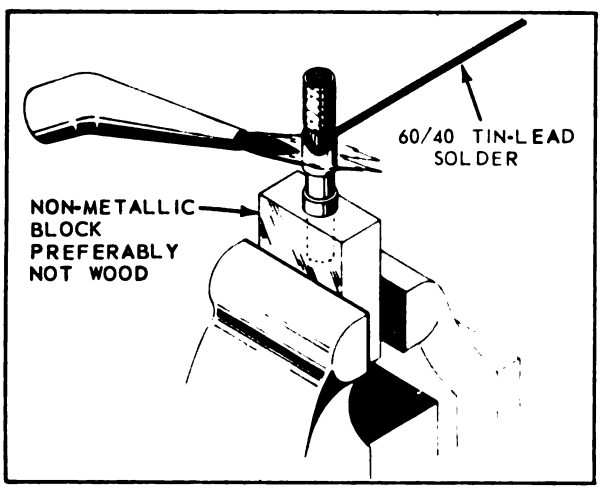


Figure 3–32. Torch Soldering Large Contact

3–45. SOLDERING IRON PROCEDURE. Soldering with an electrically heated iron is the most common procedure. For convenience either the iron or the connector is fastened to the bench as described in 3–46. Soldering is accomplished as follows:

a. Large contacts which have been removed from inserts are held in a non-metallic block and soldered by first heating the solder cup with the specially shaped tip as shown in figure 3–33. Then while heat is still applied, the pre-tinned wire is slowly inserted into the solder cup until it bottoms. Extra 60/40 rosin-core solder is added to the solder cup if necessary. Hold the hot iron to the solder cup until the solder has flowed into a smooth fillet, then allow to cool.

b. Contacts which have not been removed from inserts are soldered as shown in figures 3–34 and 3–35. The solder is flowed by placing the iron alongside the solder cup as the wire is being inserted into it. Medium size contacts such as #8 and #12 will solder more easily if the iron is held at the point where the wire touches the cutaway of the solder cup as shown in figure 3–35. Adding a small quantity of 60/40 rosin-core solder at this point will aid in carrying the heat into the joint.

CAUTION

Do not allow solder to collect outside of the solder cup. This will reduce the arc-over distance between contacts and can result in connector failure.

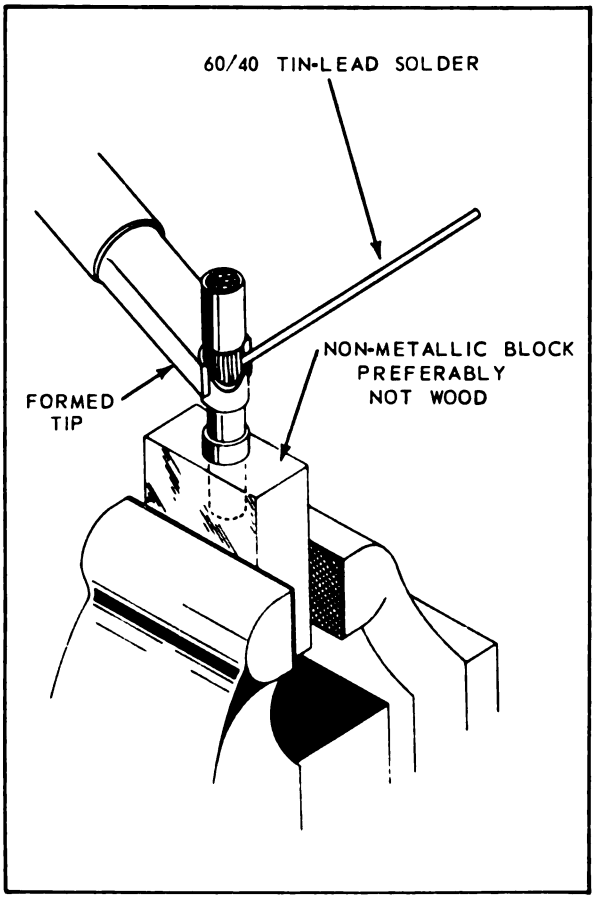


Figure 3–33. Soldering Large Size Contacts

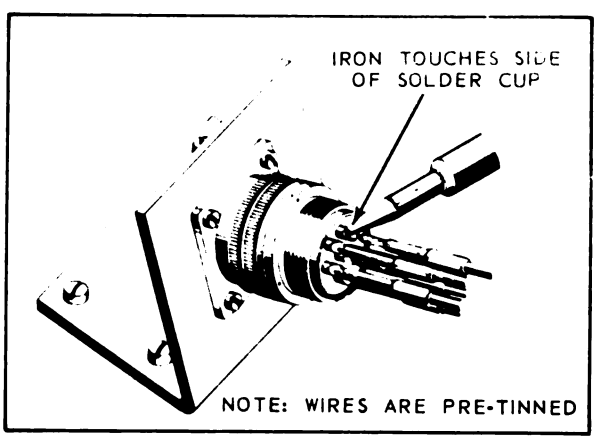


Figure 3–34. Soldering Small Size Contacts

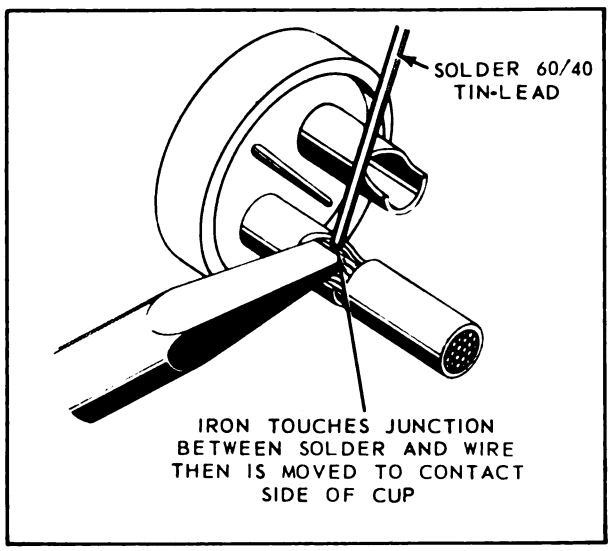


Figure 3-35. Soldering Medium Size Contacts

3-46. HOLDING CONNECTORS FOR SOLDERING. To facilitate soldering wires to contacts which have not been removed from connectors, it is helpful to either work to a fixed soldering iron or to fasten the connector into a holding fixture. If the iron is fastened to the bench, secure it into a safety screen such as shown in figure 3-36. The screen is made from expanded or perforated steel, painted to retard corrosion. To solder connectors with a fixed iron, it is necessary to hand hold the connector. If the connector is to be fastened to the bench, a steel bracket bent to a 60° - 75° angle as shown in figure 3-37 is very useful. To hold a plug use an empty shell from a mating receptacle. To hold a receptacle use two screws to mount the receptacle with the threaded portion inserted through the hole in the bracket. This will place the solder cups in position for easy soldering.

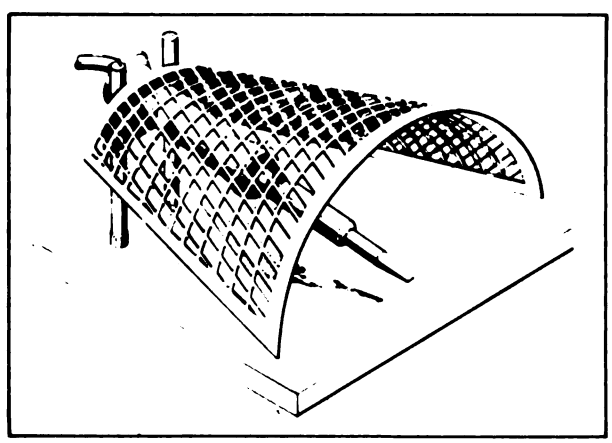


Figure 3-36. Soldering Iron in Safety Screen

3-47. SOLDERING SEQUENCE. Follow a rigid sequence in soldering wires to a connector. This helps avoid errors in wiring and also prevents burning or scorching the insulation of wires already soldered. Two useful sequences are shown in figure 3-38.

a. The soldering of the connector in figure 3-38a is started at the right or left lower edge, depending on whether the mechanic is left or right handed, and follows the bottom row across. The row above is next and is done in the same direction as the bottom row. This will permit the insert to cool between soldering operations. The operation is repeated for each row in sequence until all contacts are soldered.

Note

If wires are being soldered to a connector with a large number of contacts, plan the work to allow a cooling-off period after each series of twenty contacts in order to prevent heat build-up.

b. The sequence for the connector shown in figure 3-38b also starts with the bottom row from the right or left. The next step is to solder to the center contacts working out to each edge. The final operation is to solder wires to the top row of contacts.

The above two sequences are suggested procedures that work well in many aircraft plants. They are not mandatory but it is important for the mechanic to develop a fixed sequence and then not to deviate from that sequence.

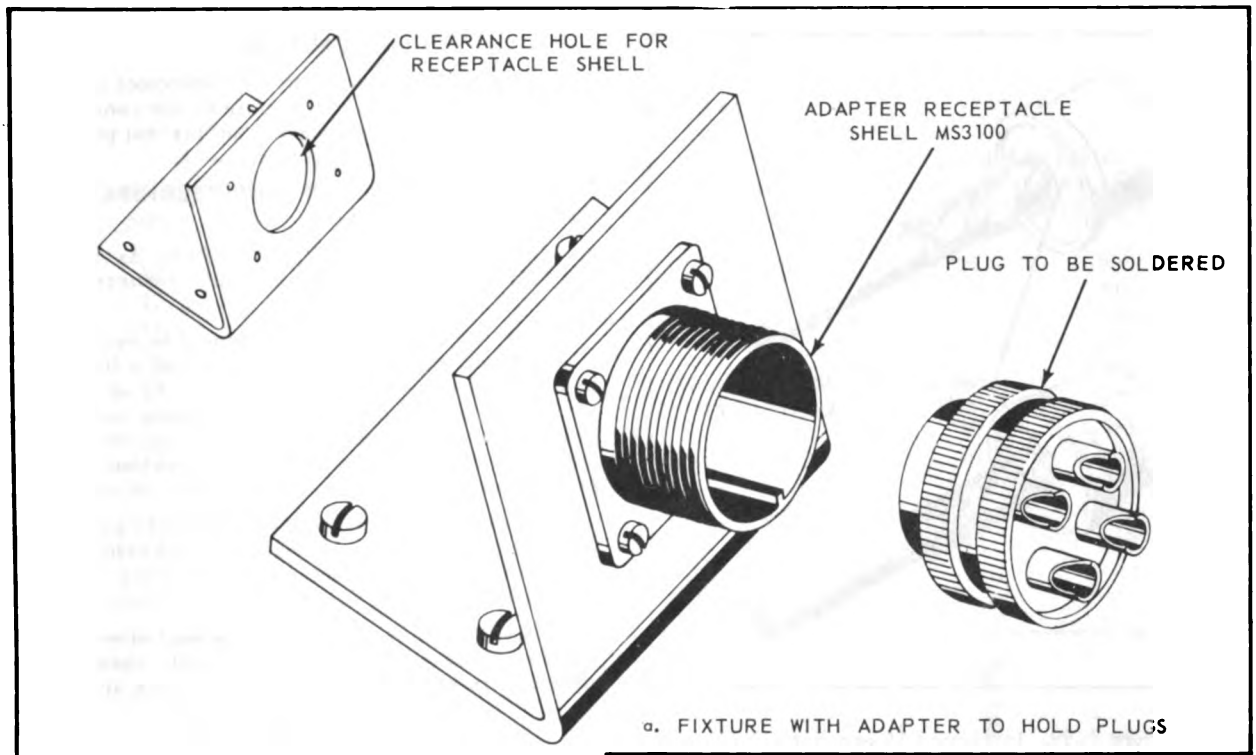
3-48. CLEANING SOLDERED CONNECTIONS. After all connections have been made, examine the connector for excess solder, cold joints and flux residues. Take following corrective measures if any of the above are found:

a. Remove excess solder by using a soldering iron which was carefully wiped clean with a heavy clean cloth.

b. Disassemble cold joints. Shake out all old solder and remake the connections using new 60/40 rosin-core solder.

c. Remove flux residues with denatured ethyl alcohol or approved proprietary solutions applied with a bristle brush. Blow the connector dry with compressed air.

3-49. INSULATING SLEEVE POSITIONING. All connectors except Class R, E, F, P and those specified in 3-39, have insulating sleeves installed over the individual wires prior to assembly to solder cups. After the connections are cleaned, push the insulating sleeves down over the contact until they bottom against the insert as shown in figure 3-39. Tie the insulating sleeves in position with nylon braid to prevent sliding back on the wires. Tie nylon sleeves individually because of nylon's stiffness. Tie all other sleeves in groups or as a complete bundle. Make sure that tie will not interfere with the MS3057 cable clamp.



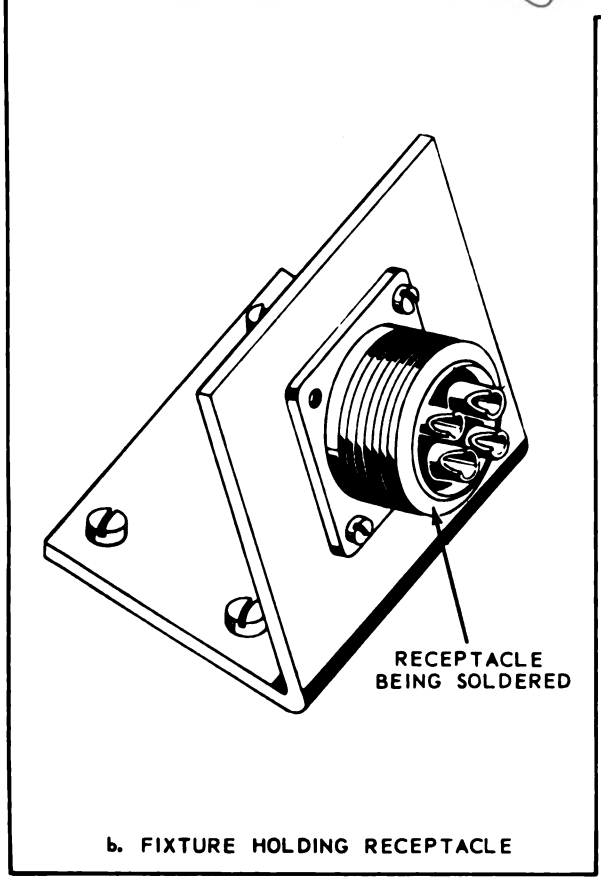


Figure 3–37. Holding Fixtures for Connectors

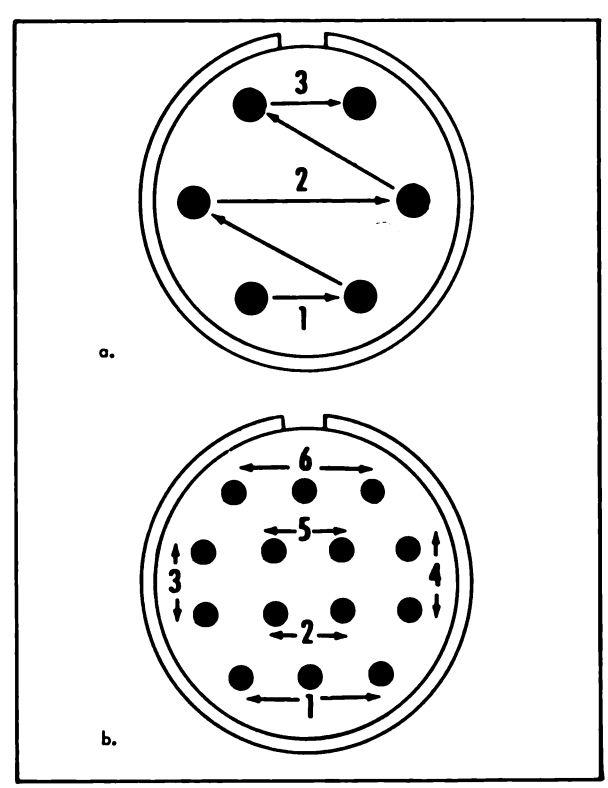


Figure 3–38. Connector Soldering Sequence

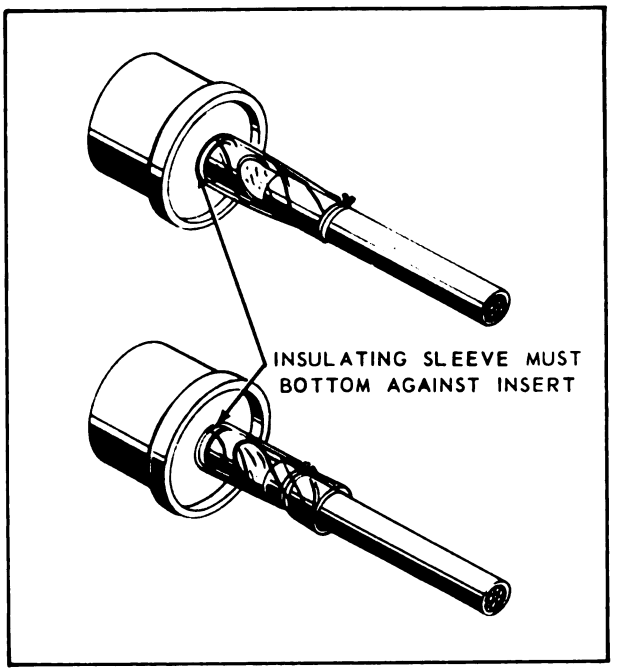


Figure 3–39. Insulating Sleeve Bottomed Against Insert

3–50. PRESHAPING WIRES. Preshape large diameter wires (No. 14 and larger) before soldering to contacts. This will avoid strain on soldered connection when MS3057 cable clamp is installed. See figure 3–40.

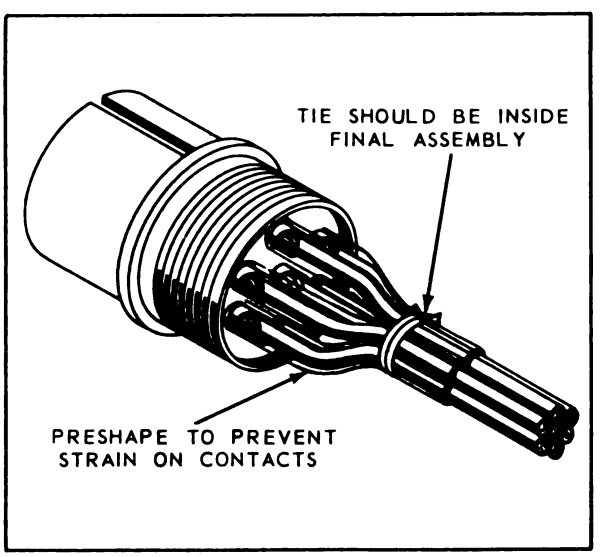


Figure 3–40. Tying Sleeves and Pre-shaping Wires

CAUTION

Preshaping is a necessity for connectors using resilient inserts. Side strain on the contacts will cause contact splaying and prevent proper mating of pin and socket contacts.

3–51. INSTALLATION OF MS3057 SERIES CONNECTOR CABLE CLAMPS.

3–52. MS3057 CABLE CLAMP TYPES. As described in 3–17, there are three types of MS3057 connector cable clamps. (See figure 3–41).

a. MS3057 has a single saddle held by two screws. It contains a metal or plastic washer and a flat rubber bushing. For shipping to prevent loss of metal or plastic washer, it is placed inside the clamp and held in place by the rubber bushing. Before using, reverse position, to that shown in figure 3–41a, so that metal or plastic washer will contact back shell of connector.

b. MS3057A has two saddles separated by a centering bar. This cable clamp is supplied with AN3420 bushing to protect wire bundle under clamp. Add extra bushings if necessary.

c. MS3057B has a gland and tapered sleeve. The gland is squeezed around the wire bundle when the cable clamp is screwed to the connector back shell.

CAUTION

Before installing MS3057 cable clamps onto connectors, screw mating part onto connector with coupling nut. This will help to prevent contacts splaying when cable clamp is tightened.

3–53. INSTALLATION OF MS3057 CABLE CLAMP. The MS3057 cable clamp is installed as follows: (See figure 3–42).

a. Slide AN3420A telescoping bushings on wire bundle if bundle diameter is too small to be effectively gripped by the saddle.

b. Slide MS3057 cable clamp without saddle on wire bundle followed by rubber bushing and metal or plastic washer.

c. Assemble wires to connector and tighten back shell. (See other paragraphs for details for each connector class.)

d. Push MS3057 cable clamp towards back shell and hand tighten. Use strap wrench to tighten fully.

e. Push AN3420A bushings, if required, into cable clamp until past saddle.

f. Attach saddle with both screws and tighten until 1/16 inch space is left between saddle and body as shown in figure 3–42. AN3420A bushing, if used, should bulge slightly when saddle is tight.

Note

A wrap of vinyl, nylon or fiber-glass tape can be used instead of AN3420A bushings. If tape wrap is used, secure with nylon braid behind saddle.

TABLE 3–10

Telescoping Bushings

Connector Size	*GROUP I Bushing No.	*GROUP II Bushing No.	*GROUP III Bushing No.	Inside Diameter in inches FREE	CLOSED
10	AN3420-3A	AN3420-3A	AN3420-3A	.125	.000
12	-4A	-4A	-4A	.219	.010
14	-6A	-6A	-6A	.312	.114
16	-8A	-8A	--------	.438	.222
18	--------	--------	-10A	.438	.200
20	-12A	-12A	--------	.541	.270
24	-16A	-16A	--------	.750	.433
30	--------	-18A	--------	.938	.504
32	-20A	--------	--------	.938	.620
36	--------	-24A	--------	1.125	.682
40	-28A	--------	--------	1.250	.816

*Bushings listed in each group will telescope respectively when free.

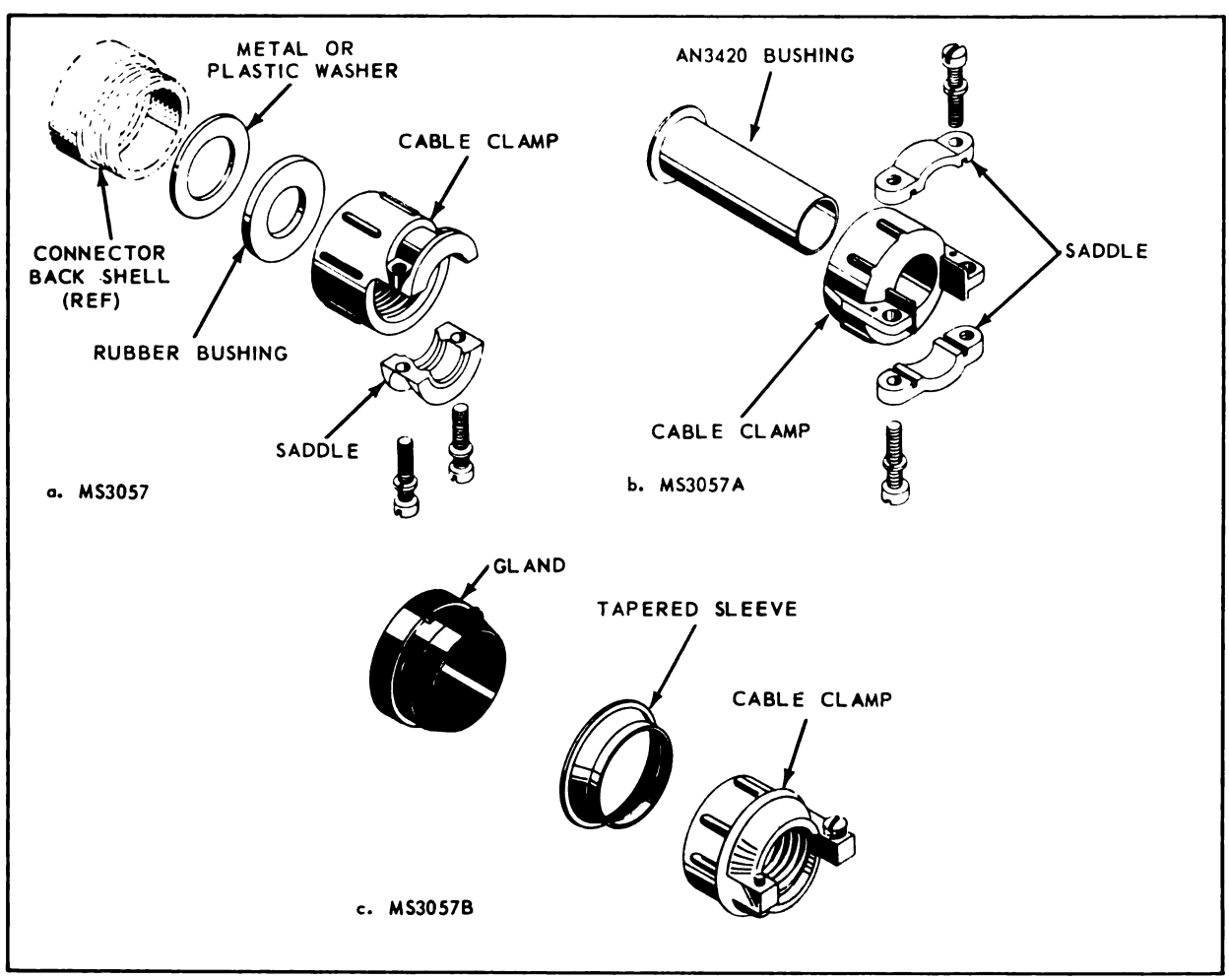


Figure 3–41. MS3057 Connector Cable Clamp Types – Exploded View

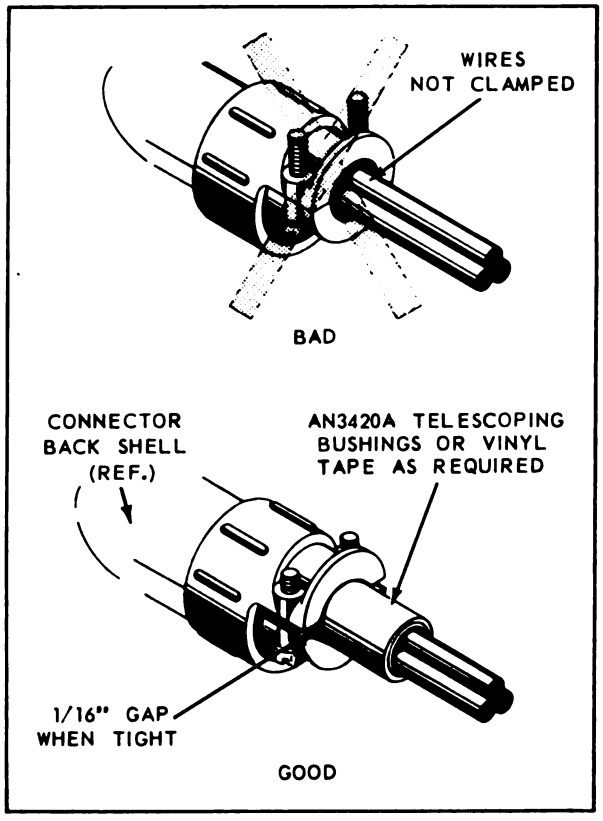


Figure 3–42. Installation of MS3057 Clamp

3–54. INSTALLATION OF MS3057A CABLE CLAMP. The MS3057A cable clamp is installed as follows: (See figure 3–43)

a. Slide MS3057A cable clamp without saddles on wire bundle before wires are connected.

b. Slide AN3420 telescoping bushing on wire bundle before wires are connected.

c. Assemble wires to connector and tighten back shell (see later paragraphs for details for each connector class).

d. Push MS3057A cable clamp together with inserted AN3420 bushing towards back shell and hand tighten. Use strap wrench to tighten fully.

e. Attach both saddles with supplied screws and lockwashers.

CAUTION

When replacing saddles, observe that screw heads are placed so that pushing on screws will tighten cable clamp to back shell.

f. Tighten saddles until 1/16 inch remains between each saddle and the centering bar as shown. Use extra AN3420 telescoping bushings in original assembly if saddles are not tight with this 1/16 inch opening. See table 3–10 for telescoping dimensions.

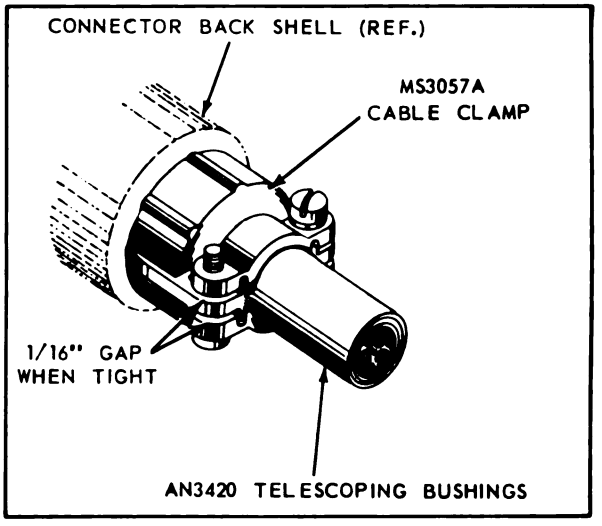


Figure 3–43. Installation of MS3057A Clamp

3–55. INSTALLATION OF MS3057B CABLE CLAMP. The MS3057B cable clamp is installed as follows: (See figure 3–44)

a. Slide AN3420A telescoping bushings, if required, on wire bundle before wires are connected. See table 3–10 for telescoping dimensions.

b. Slide MS3057B cable clamp assembly on wire bundle before wires are connected.

CAUTION

Proper lubrication of gland and tapered sleeve is important for this assembly. In handling parts, keep them clean and free of dirt. Wash away dirt with clean denatured ethyl alcohol and relubricate with petrolatum (Federal Specification VV-P-236) as shown in figure 3–45. Do not apply petrolatum to inside of gland or to serrated face of gland.

c. Assemble wires to connector and tighten back shell (see other paragraphs for details for each connector class).

d Push AN3420A bushings, if used, through gland of MS3057B so that end of bushing is flush with serrated face of gland.

e. Slide entire assembly toward back shell and hand tighten. Use strap wrench or padded jaw connector pliers to fully tighten until MS3057B bottoms onto back shell. While tightening, hold wire bundle and telescoping sleeves until gland seats on back shell.

Note

Shield braid (and jacket if present) must end outside of MS3057B cable clamp to retain moisture resistant qualtities of clamp. Ground braid to either grounding screw on cable clamp.

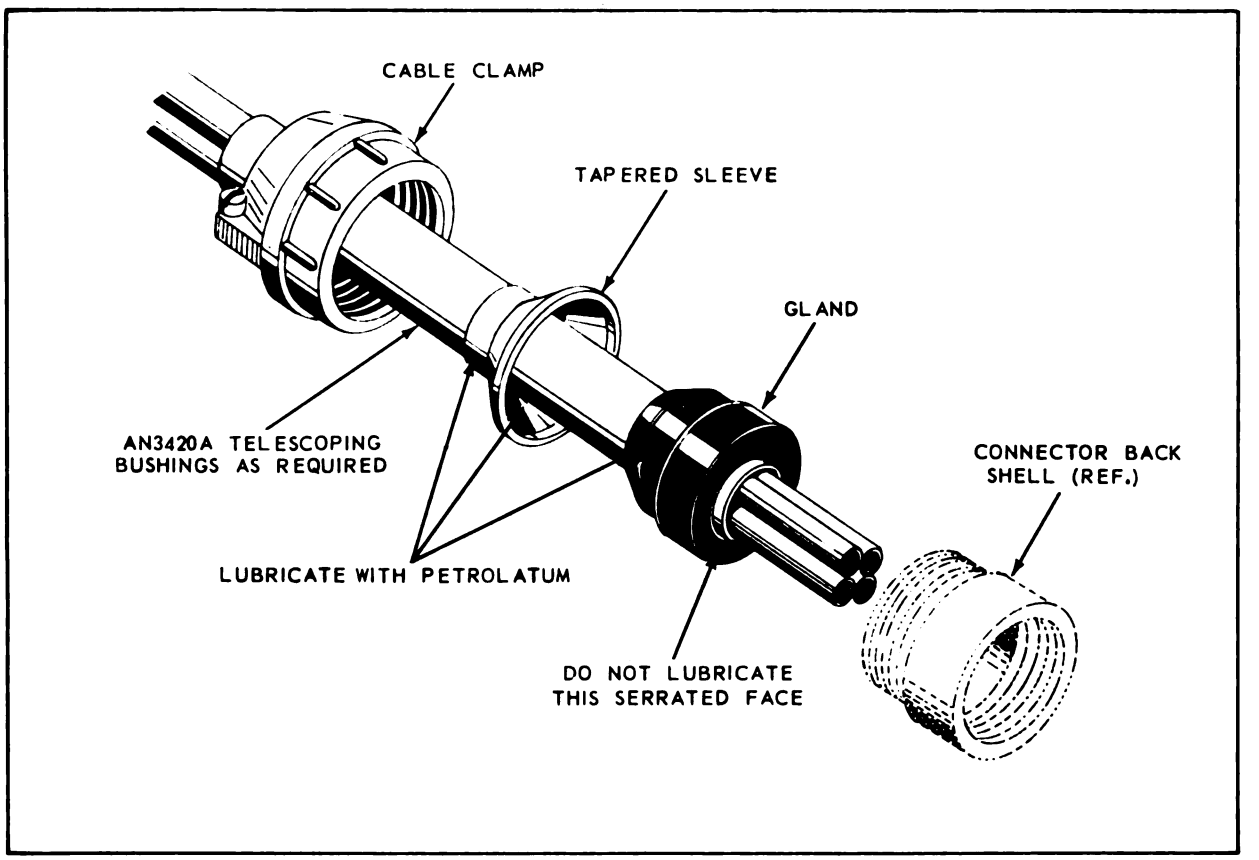


Figure 3–44. Installation of MS3057B Cable Clamp

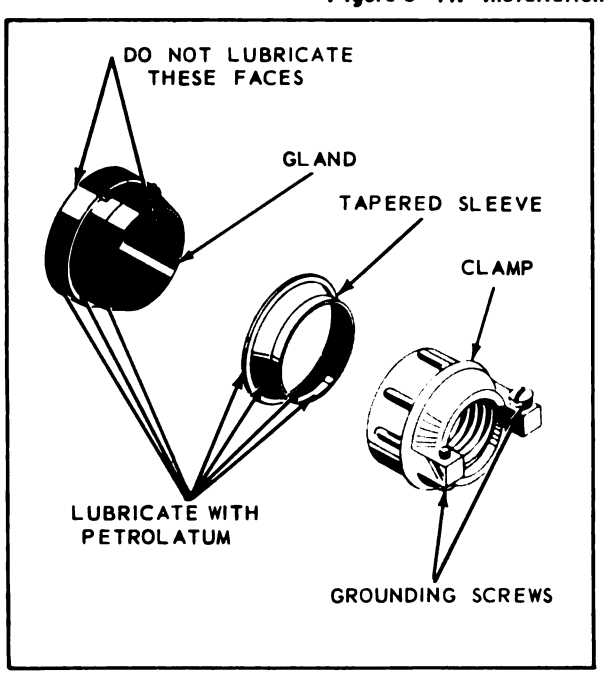


Figure 3–45. Lubrication of MS3057B Clamp

3–56. DISASSEMBLY AND REASSEMBLY OF CONNECTORS.

3–57. AMPHENOL AND CANNON MS CLASS A CONNECTORS. Amphenol and Cannon connectors are installed as follows: (See figure 3–46)

a. Remove back shell by unscrewing from body assembly. If the back shell is too tight to be loosened by hand, attach connector to mating connector shell held in fixture as illustrated in figure 3–37; and use strap wrench to loosen back shell. Do not remove coupling nut from body.

CAUTION

Never use pliers to disassemble or reassemble connectors. Use strap wrench.

b. If all contacts are size 12 or smaller, no further disassembly is required. For removal of larger contacts see 3–24.

c. Install the following items on wire bundle in listed order.

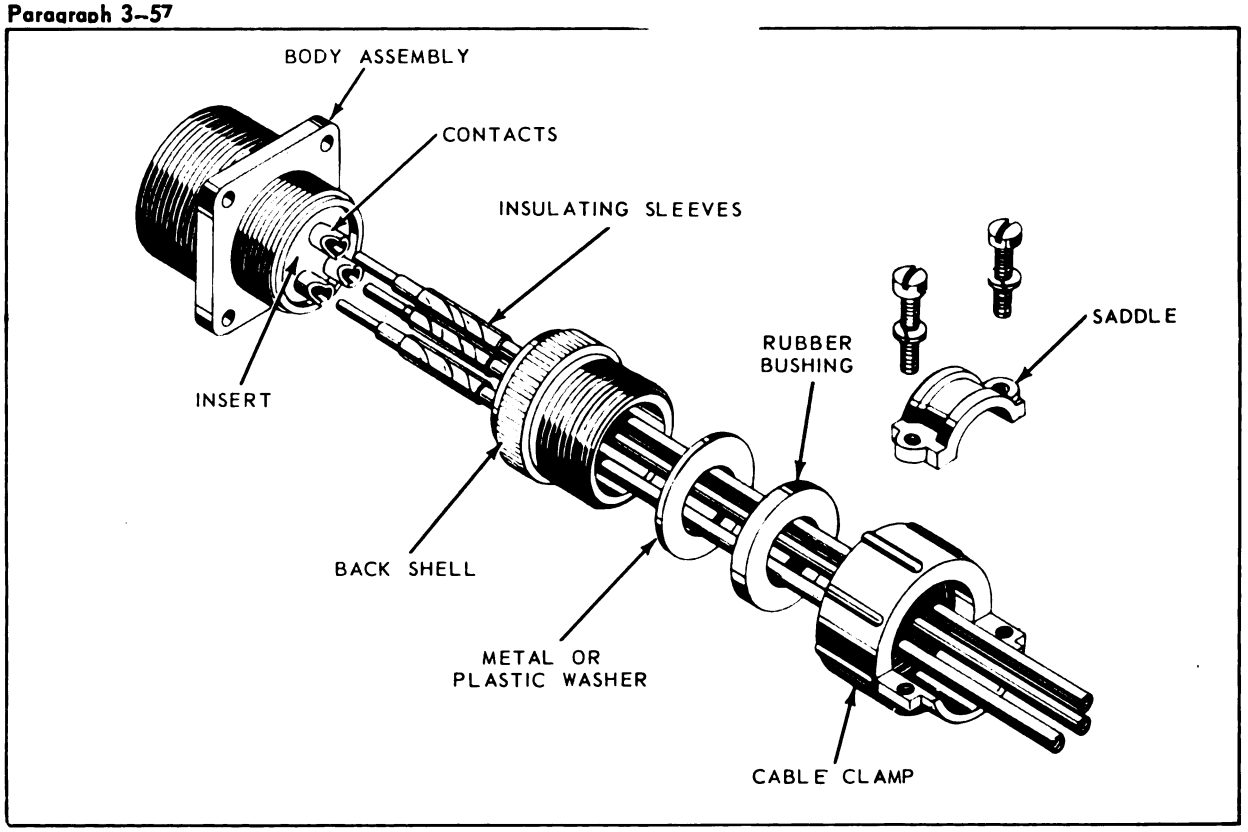


Figure 3-46. Installation of Amphenol Class A Connector

1. Cable Clamp without saddle
2. Rubber bushing
3. Metal or plastic washer
4. Back shell
5. Insert retaining ring, if removed in step b.

d. Slide insulating sleeves over each wire in bundle. Sleeves should be placed one inch back from wire ends to avoid burning during soldering operation. See 3-40 for data about insulating sleeves.

Note

Steps e through h apply only if large contacts were removed in step b.

e. Solder wires to large contacts removed in step b. See 3-42 through 3-47 for soldering instructions.

f. Reinstall large contacts by threading through rear insert and inserting contacts into front insert.

g. Reassemble inserts and contacts into body assembly. Be careful to align keyway with key. Do not force the assembly because a damaged keyway will ruin a connector.

h. Replace retaining ring so that end of ring is about 1/4 inch from removal slot as shown in figure 3-47. This will simplify future disassembly.

i. Solder wires to remaining contacts using methods described in 3-42 through 3-47.

j. Clean soldered connections and slide insulating sleeves over contacts until they bottom against insert.

k. Tie sleeves to wires using nylon braid as shown in figure 3-37.

l. Slide back shell down over wire bundle and hand tighten to body assembly. Use strap wrench to tighten back shell 1/8 turn beyond hand tight.

m. Install cable clamp as described in 3-53. or 3-54.

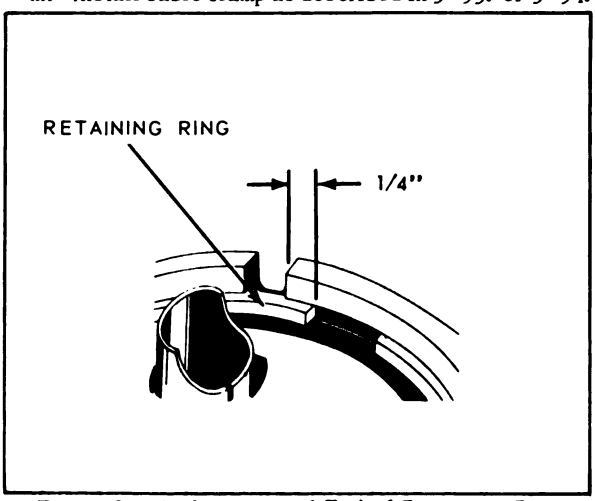


Figure 3-47. Location of End of Retaining Ring

3–58. AMPHENOL MS CLASS B CONNECTORS. Amphenol Class B connectors are installed as follows: (See figure 3–48)

a. Remove back shell by loosening captive assembly screws. Do not remove coupling nut from body.

b. If all contacts are size 12 or smaller, no further disassembly is required. For larger contacts see 3–24.

c. Install the following items on wire bundle in listed order:

1. Cable clamp without saddle
2. Rubber bushing
3. Metal or plastic washer
4. Back shell
5. Insert retaining ring, if removed in step b.

d. Slide insulating sleeves over each wire in bundle. Sleeves should be placed one inch back from wire ends to avoid burning during soldering operation. See 3–40 for data bout insulating sleeves.

Note

Steps e through h apply only if large contacts were removed in step b.

e. Solder wires to large contacts removed in step b. See 3–42 through 3–47 for soldering instructions.

f. Reinstall large contacts by threading through rear insert and inserting contacts into front insert.

g. Reassemble inserts and contacts into body assembly. Be careful to align keyway with key. Do not force the assembly because a damaged keyway will ruin a connector.

h. Replace retaining ring so that end of ring is about 1/4 inch from removal slot as shown in figure 3–47. This will simplify future disassembly.

i. Solder wires to remaining contacts using methods described in 3–42 through 3–47.

j. Clean connections and slide insulating sleeves over contacts until they bottom against insert.

k. Tie sleeves to wires using nylon braid as shown in figure 3–40.

l. Reassemble split shell. Be careful not to pinch wires.

Note

Angle back shell can be assemble at 45° angles. See engineering drawing for proper setting for each installation.

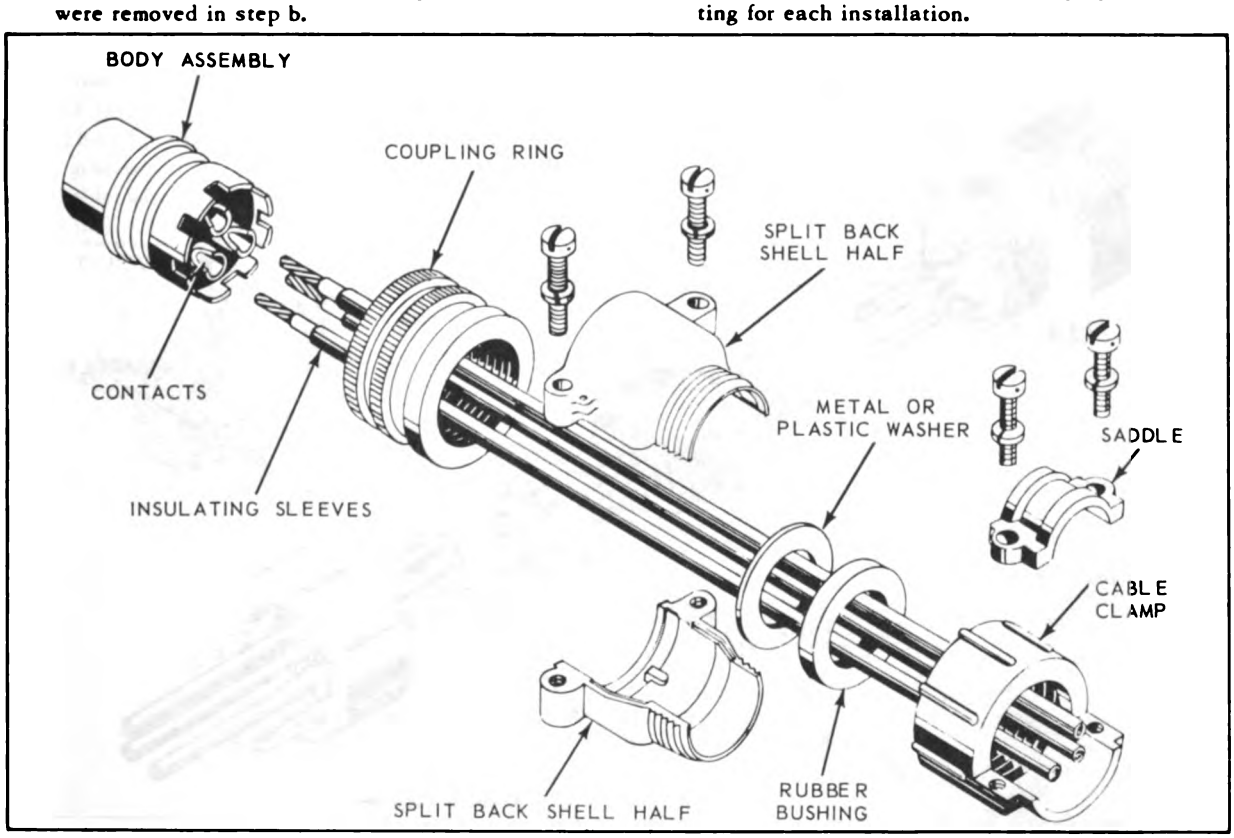


Figure 3–48. Installation of Amphenol Class B Connector

m. Install cable clamp as described in 3–53.

n. Safety wire the split back shell holding screws, if required by engineering, by passing the wire through screw heads (See figure 3–49), crossing it and completing with a twist.

3–59. AMPHENOL MS CLASS C CONNECTORS. Amphenol Class C connectors are installed as follows: (See figure 3–50)

a. Remove back shell by unscrewing from body. If the back shell is too tight to be loosened by hand, attach connector to mating connector shell held in fixture as illustrated in figure 3–37; and use strap wrench to loosen back shell. Do not remove coupling nut from plug body.

CAUTION

Never use unpadded pliers to disassemble or reassemble connectors.

b. Large contacts (8, 4 and 0) are threaded into insert. Unscrew the contact for soldering. Do not twist or attempt to remove small contacts.

CAUTION

Do not remove Class C inserts. These connectors are pressurized and insert removal will break the pressure seals.

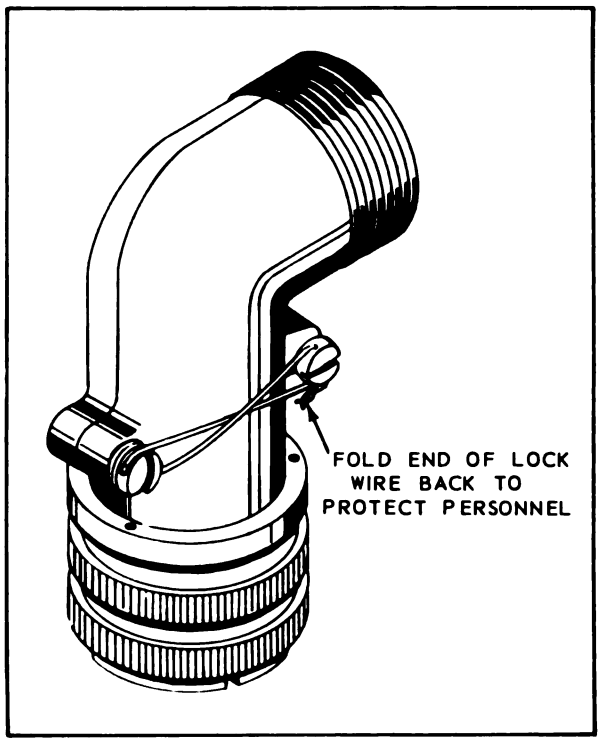


Figure 3–49. Safety Wiring Class B Connector

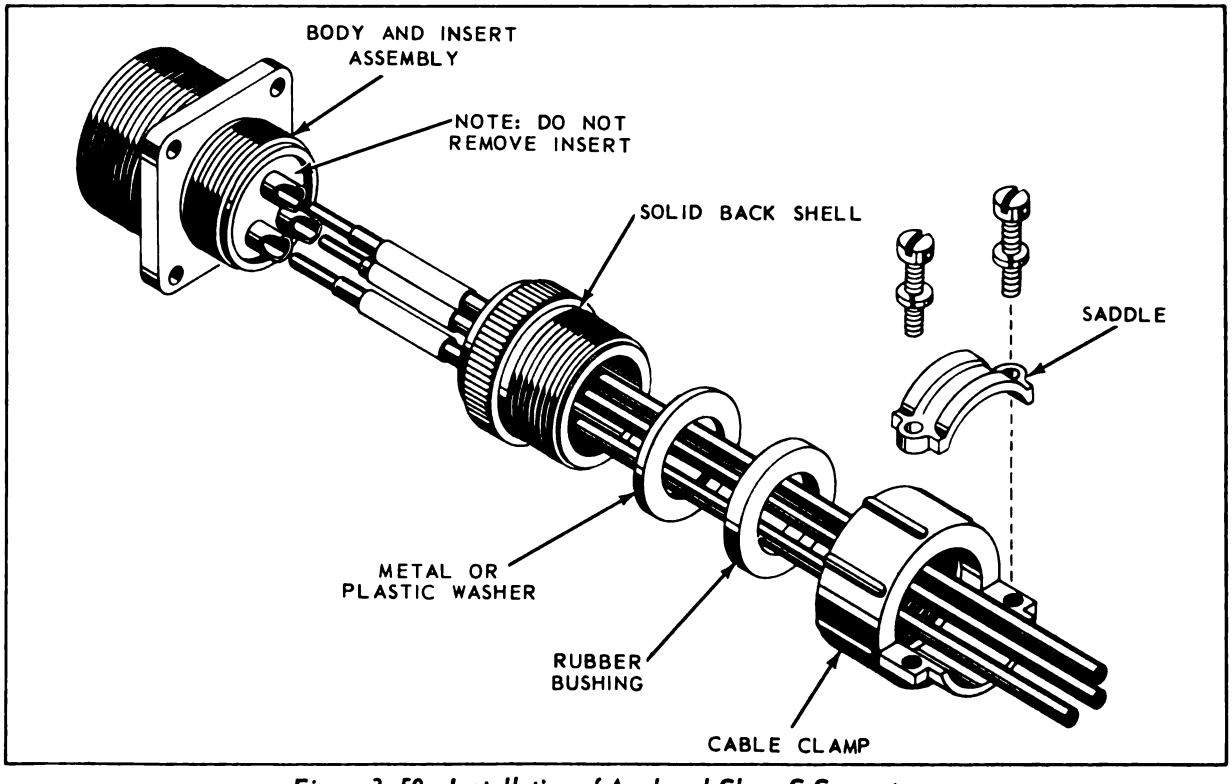


Figure 3–50. Installation of Amphenol Class C Connector

c. Install the following items on wire bundle in listed order.

1. Cable clamp without saddle
2. Rubber bushing
3. Metal or plastic washer
4. Back shell

d. Slide insulating sleeves over each wire in bundle. Sleeves should be placed one inch back from wire ends to avoid burning during soldering operation. See 3–40 for data about insulating sleeves.

e. Reinstall large contacts. Tighten contact until it is seated firmly against lead pressure washer. Use curved long nose pliers if necessary.

f. Solder wires to remaining contacts using methods described in 3–42 through 3–47.

g. Clean connections and slide insulating sleeves over contacts until they butt against the insert.

h. Tie sleeves to wires using nylon braid as shown in figure 3–40.

i. Slide back shell down over wire bundle and hand tighten to body assembly. Use strap wrench to tighten back shell 1/8 turn beyond hand tight.

j. Install cable clamp as described in 3–53.

3–60. AMPHENOL CLASS E AND CLASS R CONNECTORS. Amphenol Class E and R connectors are installed as follows:

a. Disengage the grommet compression nut assembly from the shell

b. Thread pre-tinned wires through the proper holes in the grommet.

c. Solder wires to contacts using the procedures described in 3–43 through 3–47.

d. Work the grommet compression nut assembly back up the wire bundle and engage nut with shell assembly, making sure that the grommet is drawn up flush with the insert.

e. Fill all unused grommet holes with grommet sealing plugs.

3–61. AMPHENOL FIREPROOF CONNECTORS. Amphenol fireproof connectors have crimp type contacts to withstand high temperature operating requirements. Installation is as follows:

a. Use spanner wrench to remove spanner nut. See figure 3–51.

b. Tap body assembly lightly in palm of hand to remove and separate contact and insert assembly.

c. Install the following items on wire bundle in listed order:

1. Conduit with coupling nut or other required fittings.

Note

Fitting threads are not identical with standard MS connectors of same size. Use fitting sizes listed in table 3–11.

TABLE 3–11

Amphenol Fireproof Connector Fittings

Connector Size	Fitting Size	Fitting Thread
18	12	1-3/16 - 18
22	16	1-7/16 - 18
32	24	2 - 18
36	28	2-1/4 - 16

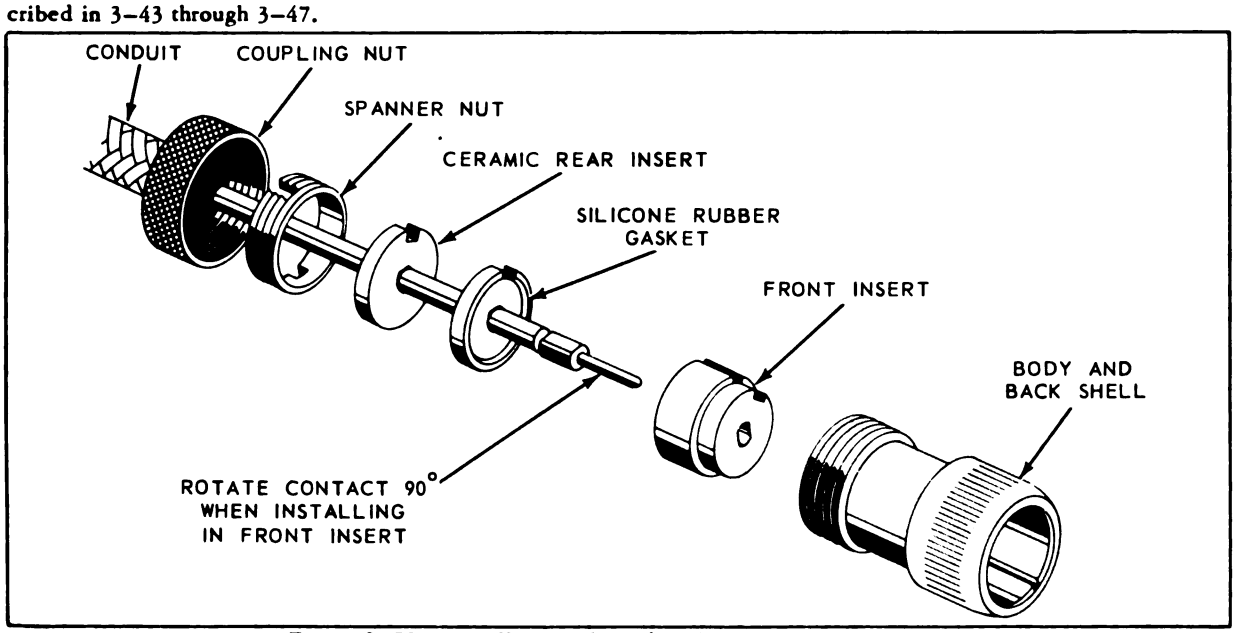


Figure 3–51. Installation of Amphenol Fireproof Connector

2. Spanner nut
3. Ceramic rear insert
4. Silicone rubber gasket

d. Crimp wires into contacts using any of the methods described in section V.

e. Reassemble by (1) sliding contacts into ceramic front insert; (2) pushing silicone rubber gasket down over contacts; and (3) sliding ceramic rear insert over contacts.

f. Examine contact and insert assembly to see that parts butt and then slide assembly into body. Tighten spanner nut into place until flush with rear of body shell.

g. Tighten conduit coupling nut or other required fitting over body assembly. Use strap wrench to tighten 1/8 turn beyond hand tight.

3–62. POTTING CONNECTORS. Potting connectors are supplied with a plastic potting mold. Installation is as follows:

a. Slide the plastic mold over the wire bundle.

b. Solder wires to contacts. See 3–43 through 3–47 for soldering instructions.

CAUTION

Do not install insulating sleeves over individual wires. Potting compound will not cure properly in contact with vinyl sleeving.

c. Install spare wires on all unused pins. Use largest gage wire that would normally be attached to each contact. Spare wires are approximately 9 inches long. (See figure 3–52).

d. Clean the complete connector assembly by scraping off rosin and then brush vigorously in new unused Stoddard's Solvent followed by second rinse in clean Stoddard's Solvent. See figure 3–53.

e. Rinse area to be potted with methylene chloride applied from hand operated laboratory wash bottle or similar device.

CAUTION

Do not breathe methylene chloride fumes. Use only in well ventilated area.

Note

Complete potting within two hours after cleaning.

f. Slide plastic mold into position.

CAUTION

Mate connectors before potting either part to avoid splaying contacts during the potting operation.

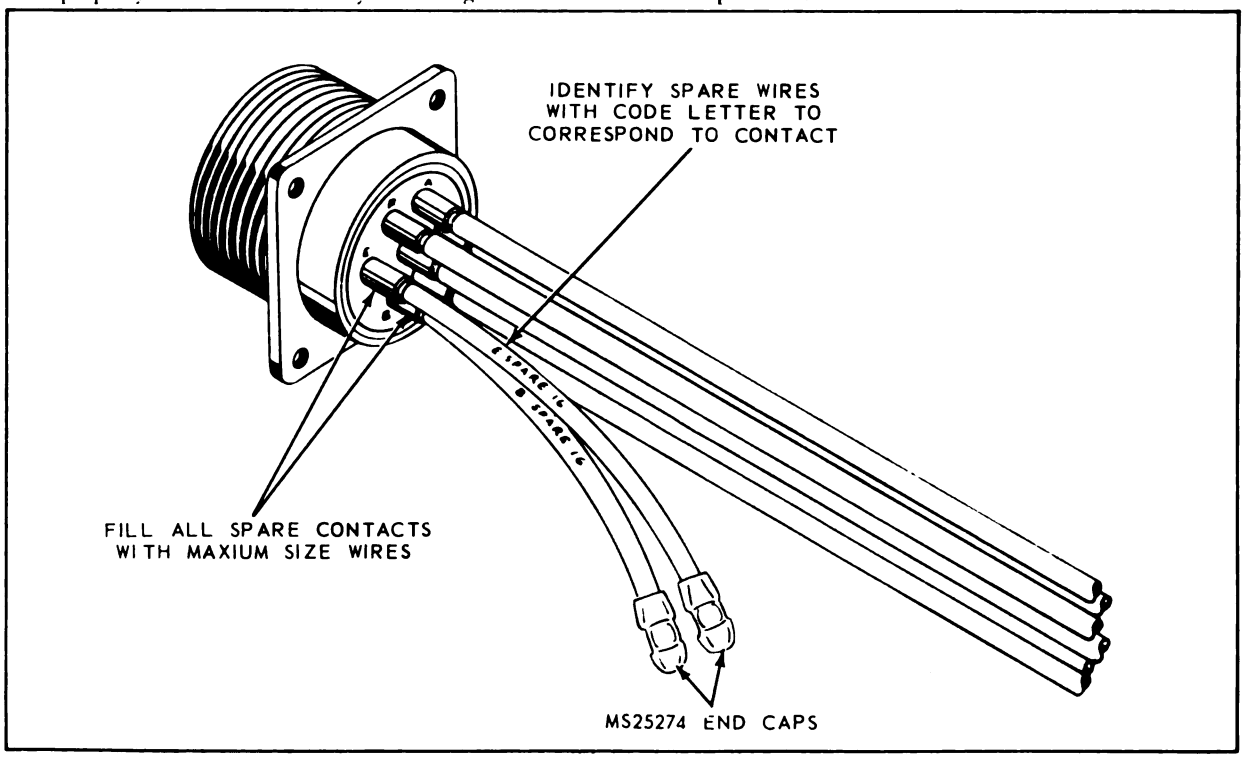


Figure 3–52. Spare Wires for Potting Connector

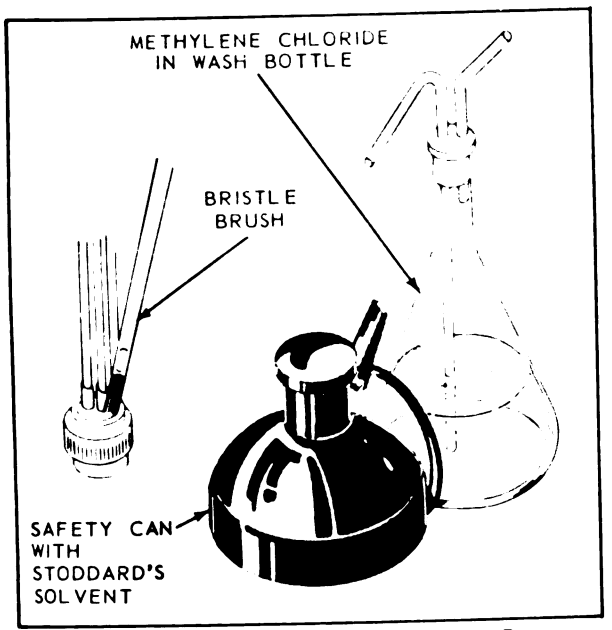


Figure 3–53. Cleaning Connector Prior to Potting

g. Insert potting compound prepared in accordance with directions given in section X. Fill back of connector by inserting nozzle down between wires until it almost touches back of insert (See figure 3–64). Fill slowly while moving nozzle back from insert and watch compound to be sure no air bubbles are trapped. Fill to top of mold. Tamp down the compound, if necessary, with a wooden or metal 1/8 inch dowel. Tap connector assembly on a resilient surface or vibrate mechanically to help flow the compound into all spaces and to release trapped air.

h. Insulate the ends of all spare wires. See figure 3–52. The preferred method of insulating a spare wire is to crimp it into an MS25274 wire end cap with tool MS25037-1A. See 3–63 for installing procedure. Nonstandard end caps are also available for either stripped or unstripped wire.

i. Immediately after filling each connector, tie the wires together loosely about 6 inches back from connector. Make sure that wires are centrally located in the connector so that each wire is completely surrounded by potting compound. Suspend the assembly by placing the tie over a nail as shown in figure 3–54 and allow to air cure for at least 1–1/2 hours at 75°F without any movement.

WARNING

The accelerator contains a toxic lead compound. Avoid excessive skin contact. Clean hands thoroughly after using. Use gloves.

j. Carefully place assembly still suspended from nail into drying oven for 3 to 4 hours at 100°F, or air cure at 75°F for 24 hours.

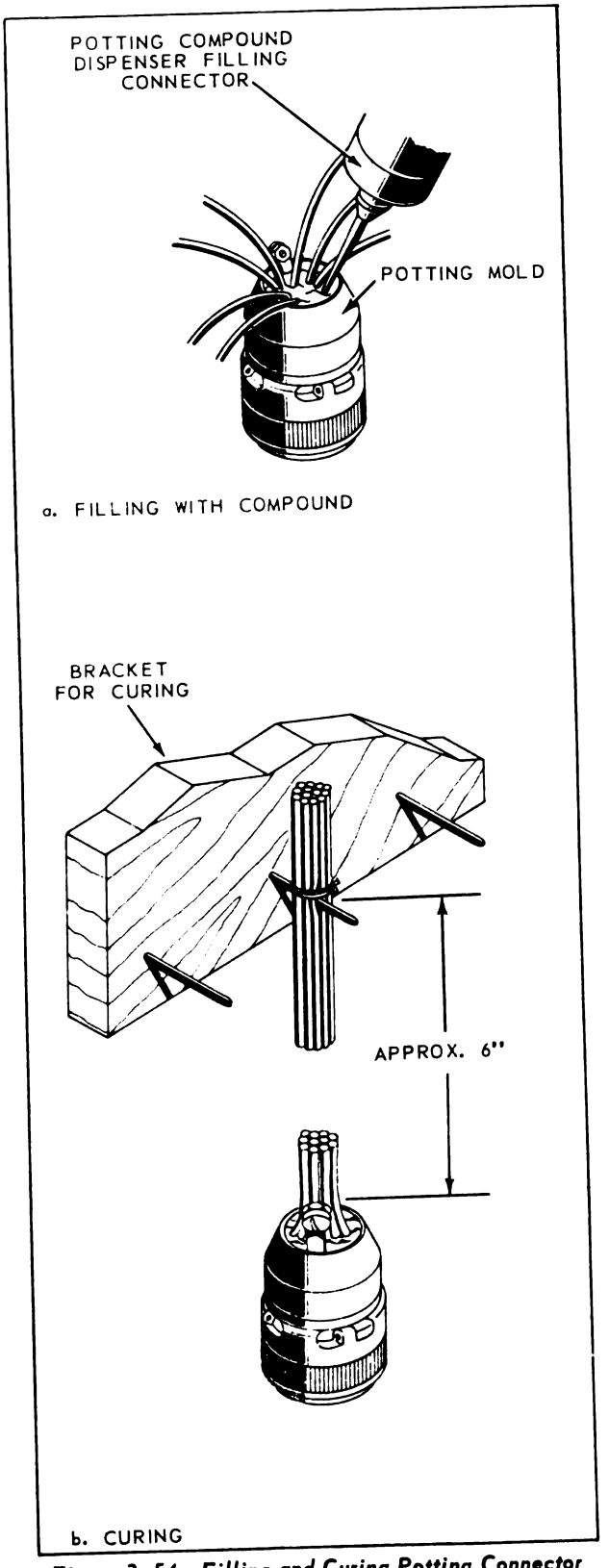


Figure 3–54. Filling and Curing Potting Connector

WARNING

The accelerator contains a toxic lead compound. Avoid excessive skin contact. Clean hands thoroughly after using. Use gloves.

Note

Full cure with maximum electrical characteristics is not achieved until 24 hours after potting. Do not perform any electrical insulation resistance tests until this period has passed.

k. Apply a light film of lubrication oil to all exterior metal surfaces after potting compound is completely cured.

l. If the plug does not have an O-ring or gasket seal on the barrel as shown in figure 3-55 then install an MS29513 O-ring selected from table 3-12. Roll O-ring tightly against shoulder of plug inside coupling ring. Plug barrel and O-ring must be clean and dry before assembly.

CAUTION

Do not use two rings. The added thickness of a second ring will prevent proper mating of contacts.

3-63. PROCEDURE FOR CRIMPING WIRE END CAPS ONTO SPARE WIRES. The procedure for crimping wire end caps with standard tool MS25037-1A is as follows:

a. Select an end cap of the correct size for the wire to be insulated from table 3-13, and crimp it to the wire with the MS25037 tool.

TABLE 3-13

Wire End Caps and Crimping Tools

MS Number	Color	Wire Size
MS25274-1	Yellow	26 - 24
MS25274-2	Red	22 - 18
MS25274-3	Blue	16 - 14
MS25274-4	Yellow	12 - 10

b. Make sure the locator is properly positioned behind the lower nest. Position the wire end cap in the correct die nest (color of cap insulation matches color coding on tool handle) with the closed end of the cap resting against the locator.

c. Insert the stripped wire so that the end of the stripped wire is seated against the closed end of the cap, and the insulation against the metal sleeve of the cap.

d. Close tool handles to crimp end cap to wire, until ratchet releases and the tool opens. Remove the crimped assembly.

3-64. BENDIX - SCINTILLA MS CLASS A CONNECTORS. Bendix Class A connectors are installed as follows: (See figure 3-56)

a. Remove back shell by unscrewing from body. If the back shell is too tight to be loosened by hand, attach the connector to mating connector shell attached to fixture as illustrated in figure 3-37; and use a strap wrench or padded jaw pliers to loosen back shell. Do not remove coupling nut from plug body.

TABLE 3-12

O-Ring Sizes for AN Type Connectors

Plug Size	O-Ring Thickness	O-Ring ID	MS29513 Dash Nos.
8S	.070 inches	.312 inches	-10
10S & 10SL	.070 inches	.364	-12
12 & 12S	.070	.489	- 14
14 & 14S	.070	.489	-14
16 & 16S	.070	.614	-16
18	.070	.739	-18
20	.070	.864	-20
22	.070	.989	-22
24	.070	1.114	-24
28	.070	1.364	-28
32	.070	1.364	-28
36	.103	1.737	-132
40	.103	1.987	-136
44	.103	2.237	-140
48	.103	2.487	-144

CAUTION

Never use pliers with unpadded jaws to disassemble or reassemble connectors.

b. If all contacts are size 12 or smaller, no further disassembly is required. Larger contacts such as size 8, 4 or 0 may be removed by applying pressure on solder well end by means of steel or bakelite rod slightly smaller in diameter than the solder well. See figure 3-22 for arbor press fixture suitable for this operation. Table 3-14 lists diameter of rods for removing contacts.

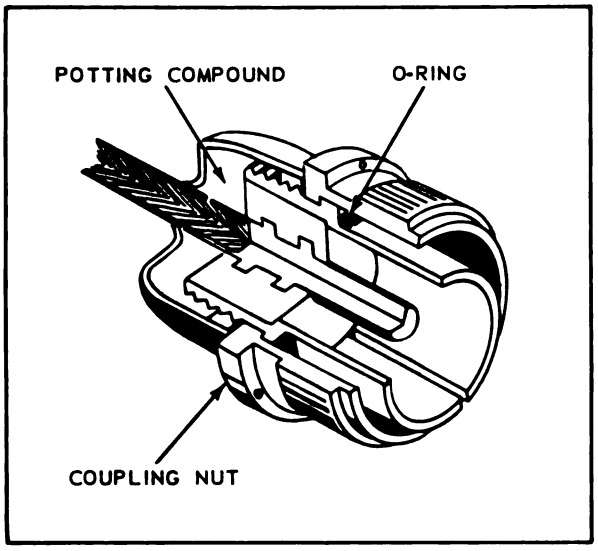


Figure 3-55. Installation of O-Ring on Potted Connector

CAUTION

Hold the connector so that pressure is applied in a straight line with contacts. Pushing at an angle may damage the contacts. Bent contacts must be replaced. Do not attempt to straighten damaged contacts.

c. Install MS3057B cable clamp as described in 3-55.

d. Slide insulating sleeves over each wire in bundle. Sleeves should be placed one inch back from wire ends to avoid burning during soldering operation. See table 3-9 for sleeving sizes.

e. Solder wires to larger contacts removed in step b. See 3-43 through 3-47 for soldering instructions.

f. Reinstall large contacts by pushing them through rear of insert until seated. Use ethyl alcohol as a lubricant, if necessary. Install each contact, when cool, before proceeding to solder next contact. This will help avoid errors. Use a bakelite screwdriver to aid in seating contacts. (See figure 3-57).

TABLE 3-14

Contact Removal Tool Diameter

Contact Size	Rod Diameter (inches)
0	.450
4	.312
8	.187

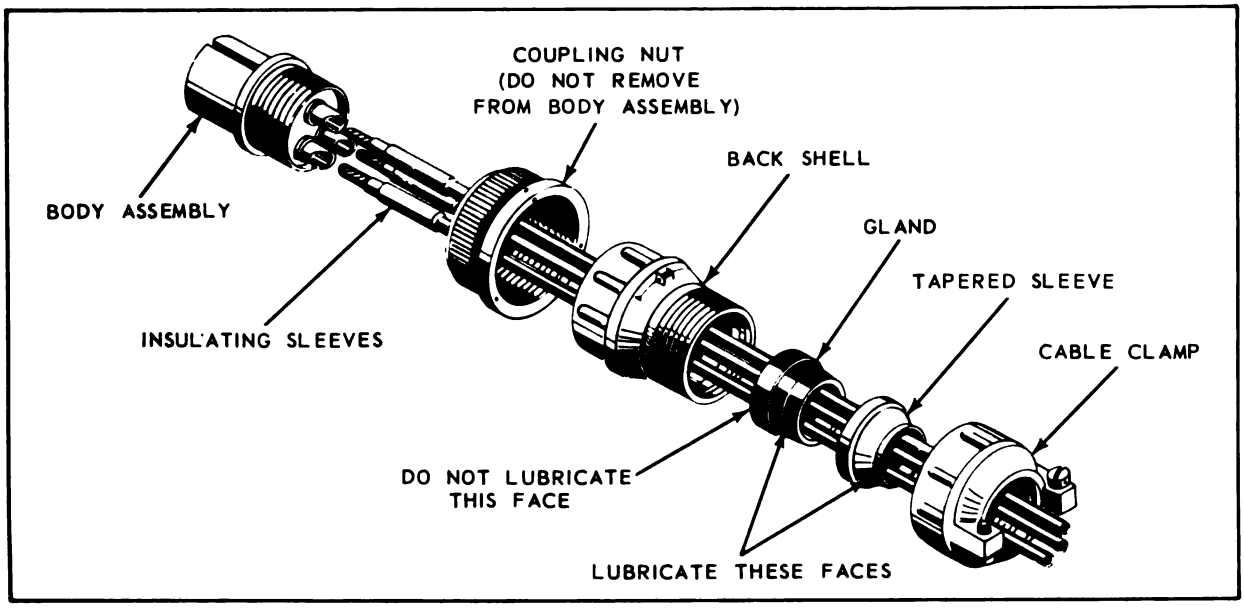


Figure 3-56. Installation of Bendix Class A and C Connector

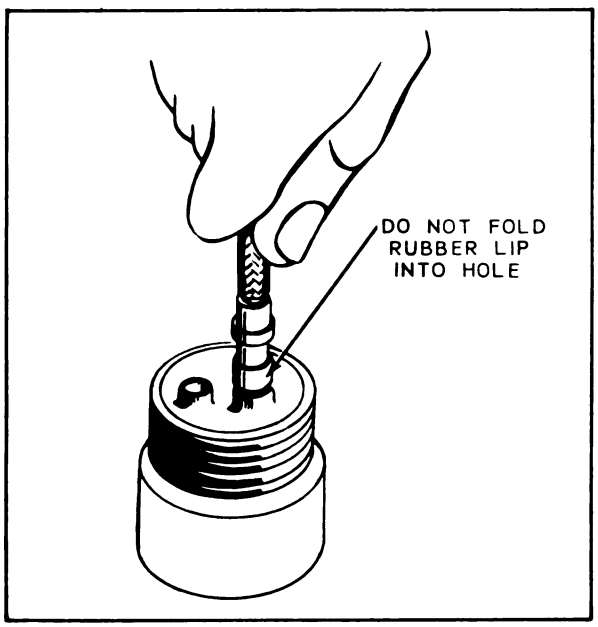


Figure 3-57. Reinstalling Contact in Bendix Resilient Insert

CAUTION

Use care not to fold thin lip of rubber into hole with contact.

g. Solder wire to remaining smaller contacts using one of the methods described in 3-42 through 3-47.

h. Slide insulating sleeves over cooled connections until they bottom against insert.

i. Slide back shell down over wire bundle and hand tighten to body. Use strap wrench or padded jaw pliers to tighten back shell until it bottoms.

j. Slide telescoping sleeves, if required, through gland until flush with inside edge. Hold telescoping sleeves in back of cable clamping nut while engaging threads. Do not release telescoping sleeves until gland seats on back shell. See 3-55 for details.

k. Tighten cable clamp with strap wrench or padded jaw pliers until it bottoms. Mate connector with mating shell in fixture while tightening cable clamp.

CAUTION

Keep all parts free of dirt and foreign material. Clean dirty parts with ethyl alcohol and relubricate all threads with Military Specification MIL-G-3278 grease. Relubricate the indicated parts of gland and tapered sleeve as shown in figure 3-45 with petrolatum.

3-65. BENDIX-SCINTILLA MS CLASS C CONNECTORS. Bendix Class C connectors are pressurized and care must be given to avoid breaking the pressure seal. Installation procedure for Bendix Class C connectors is the same as for Bendix Class A connectors. (See figure 3-56).

CAUTION

Never remove insert or contacts from Class C connector as this would break the pressure seal incorporated in the unit at the time of factory assembly.

3-66. BENDIX-SCINTILLA MS CLASS E CONNECTORS. Bendix Class E connectors are installed as follows:

a. Remove cable clamp by unscrewing from back shell. Slide cable clamp over wire bundle.

b. Check tapered sleeve and grommet for thin film petrolatum lubricant on indicated surfaces. (See figure 3-58).

c. Slide tapered sleeve over wire bundle.

d. Insert pretinned wires through proper holes in grommet.

Note

Grommet is coded to match insert coding.

Use alcohol as a lubricant if necessary. After wires are threaded through grommet, use air blast to dry alcohol.

e. Unscrew back shell from body assembly and slide over wire bundle. If coupling nut is removed, push nut back on wire bundle with threaded end forward.

f. Install insulating sleeves on wires

g. Solder wires to contacts as described for Bendix-Scintilla Class A connectors in 3-64.

CAUTION

Do not remove contacts from receptacles for soldering.

h. Slide insulating sleeves over cooled connections until they bottom against insert.

i. Slide back shell down over wire bundle and hand tighten to body shell.

j. Examine insulating sleeves. They should not project over shoulder in back shell.

k. Use strap wrench or padded jaw pliers to tighten back shell until it bottoms.

l. Carefully push grommet down over wire until it is seated in shoulder of back shell.

CAUTION

Do not allow wires to fold inside back shell.

m. Fill all unused holes with MS25251 grommet sealing plugs. Sizes are listed in table 3-15.

n. Slide tapered sleeve and cable clamp over grommet and hand tighten.

o. Tighten cable clamp with strap wrench or padded jaw pliers until it bottoms.

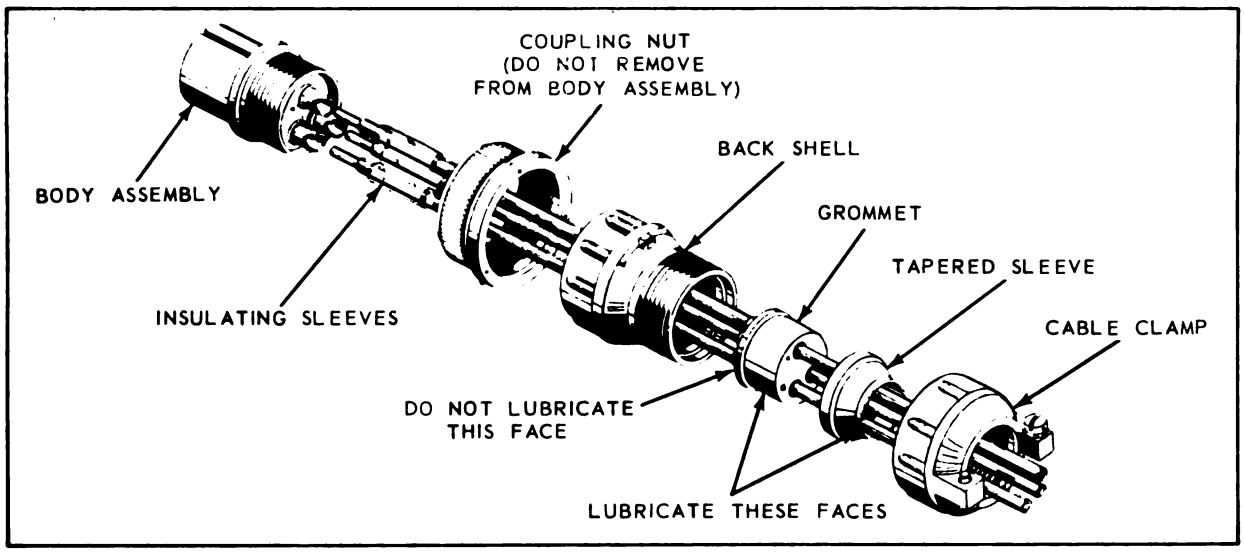


Figure 3–58. Installation of Bendix Class E Connector

CAUTION

When tightening cable clamp insure that tapered sleeve and grommet do not rotate with cable clamp. This will cause tension and possible breakage of wire at connection.

3–67. BENDIX-SCINTILLA MS CLASS R CONNECTORS. Bendix Class R connectors are installed as follows: (See figure 3–59).

a. Remove compression sleeve from back nut by unscrewing the two compression screws, and slide sleeve over wire bundle.

b. Insert pretinned wires through the proper holes in grommet and slide along the wire bundle.

Note

Use identifying letters on the rear face of the grommet as a guide in threading wires. Align letters with corresponding letters on rear face of the insert.

TABLE 3–15

Sizes of Grommet Sealing Plugs

Wire Size	MS Part No.
22 - 16	MS25251-16
14 - 12	MS25251-12
10 - 8	MS25251- 8

c. Unscrew the back nut from the body assembly and slide it over the wire bundle. If coupling nut is removed, make sure it is pushed back on the wire bundle with the threaded end forward.

d. Solder wires to contacts using the procedures for Bendix Class A connectors as described in 3–64.

e. Mate connector with its mating piece and slide back nut down over wire bundle and hand tighten to shell. Use a strap wrench or padded jaw connector pliers to tighten back nut until it bottoms.

f. Push grommet carefully down over wires until it is seated in shoulder of back nut.

g. Fill all unused grommet holes with MS25251 grommet sealing plugs; sizes are listed in table 3–15.

h. Slide the grommet compression sleeve down over the wire bundle and tighten the two compression screws until they bottom.

3–68. BENDIX-SCINTILLA FIREPROOF CONNECTORS. Bendix fireproof connectors have crimp-on type contacts to withstand high temperature operating requirements. Installation is as follows: (See figures 3–60 and 3–61).

a. Remove back shell by unscrewing from body.

b. Remove threaded insert retaining ring with fingers. If necessary, use spanner wrench (Bendix 11-4045).

c. Remove insert assembly by pushing on front insert toward the rear of the connector.

d. Remove front insert from contacts. Revolve contacts 90° and remove from rear insert and sealing insert.

Note

Use care to prevent tearing or cutting sealing insert.

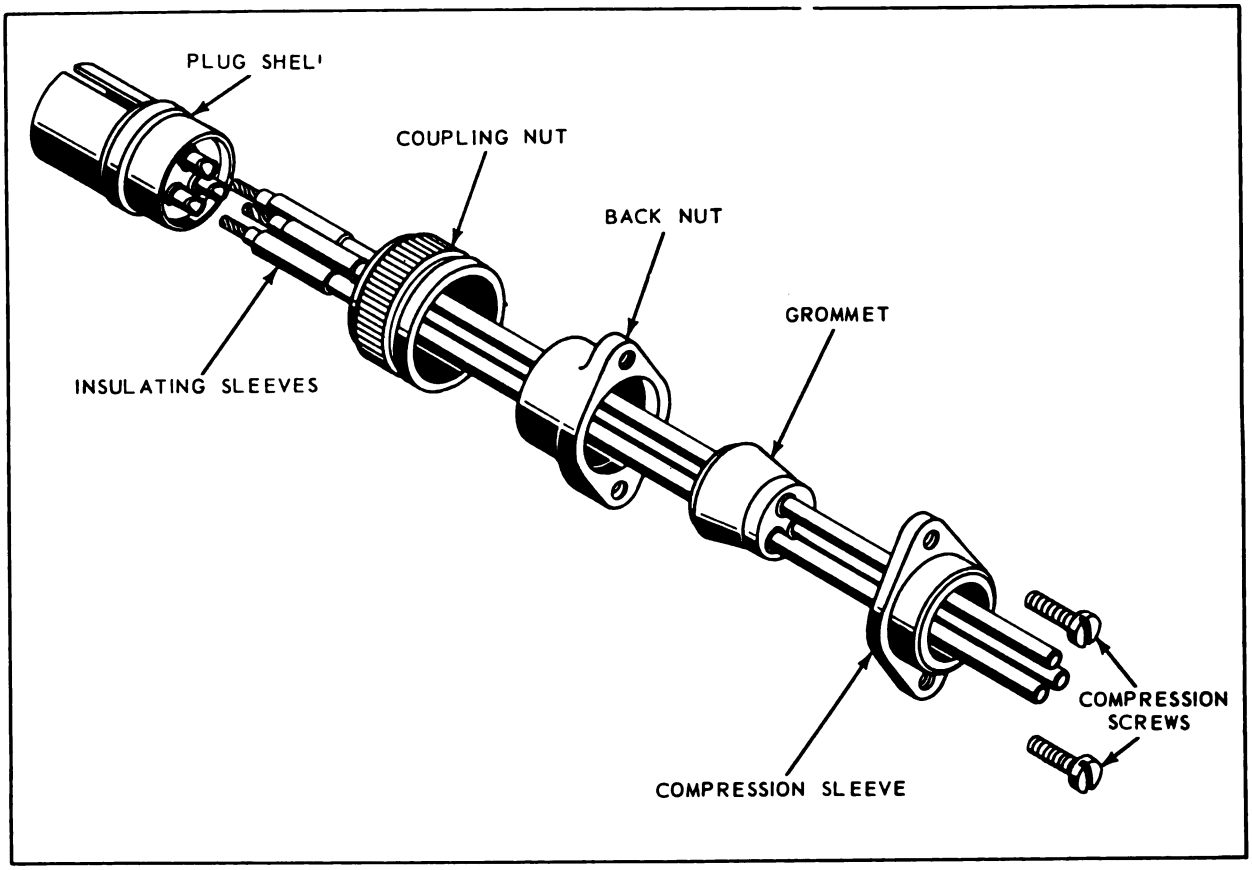


Figure 3–59. Installation of Bendix Class R Connector

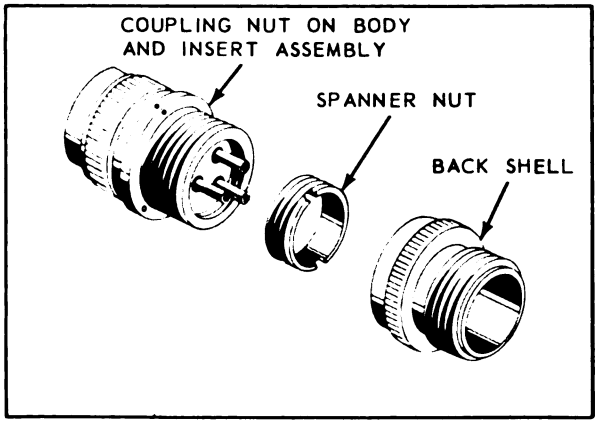


Figure 3–60. Bendix Fireproof Connector Partial Disassembly

e. Strip wires.

f. Attach wires to contacts by silver soldering or crimping with appropriate tool.

g. Install the following on the wire bundle in the order given:

1. Elbow and adapter or other fittings as required.
2. Threaded insert retaining ring.

h. To install contacts with wires attached, rotate contacts 90° and insert contacts through proper holes of rear insert.

Note

Smallest outside diameter of rear insert must face wires.

i. Push sealing insert over contacts until it butts against front face of rear insert.

j. Align keyway of front insert with keyway of rear insert and slide front insert (largest diameter first) over contacts down to sealing insert.

k. Align keyway of assembled inserts with keyway in body. Carefully push assembly into back of body. If sealing insert catches on key, depress insert with a dull instrument while it passes under the key.

l. Start spanner nut into connector body by hand and tighten with spanner wrench (see table 3–16), using standard torque wrench handle (1/4 inch drive), as shown in figure 3–62. Tighten to torque values in table 3–16.

m. Tighten back shell, or elbow if used, to body. Use strap wrench or padded jaw pliers to tighten until back shell is bottomed.

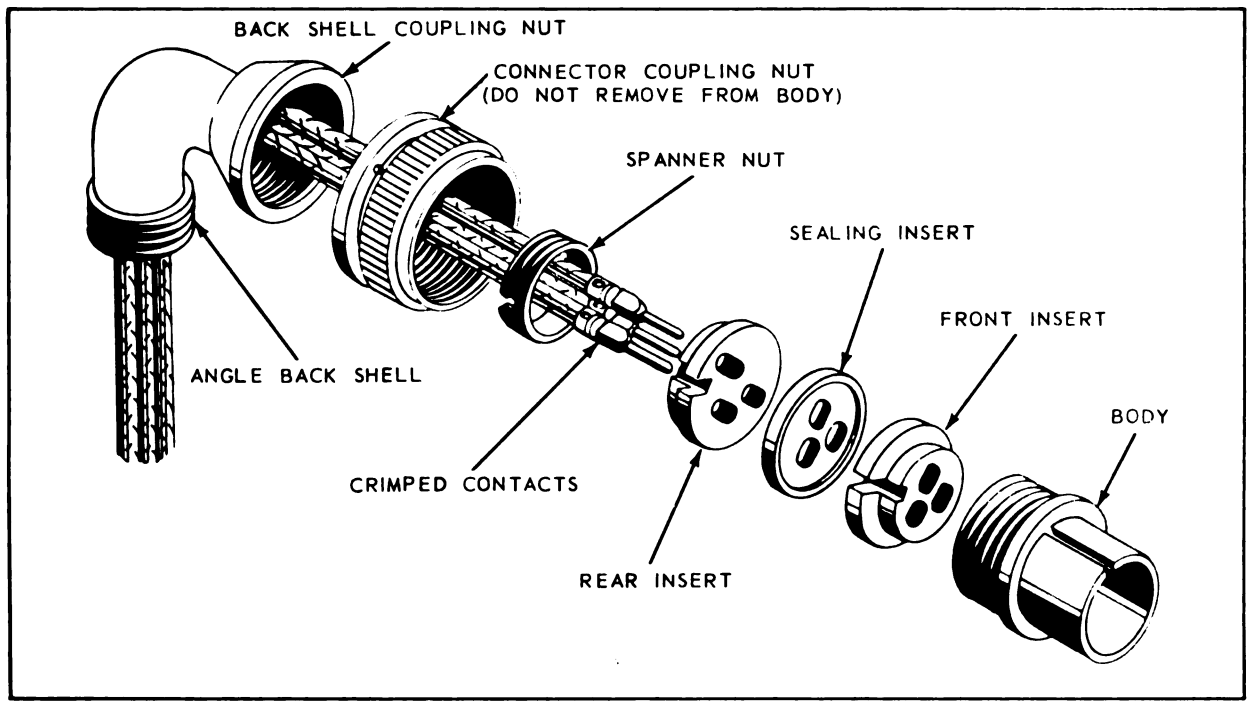


Figure 3–61. Installation of Bendix Fireproof Connector

TABLE 3–16

Torque Value for Fireproof Connectors

Connector Size	Spanner Wrench (Bendix)	Torque
10S	11-4045-10	10lb in.
12S & 12	-12	12
14S & 14	-14	14
16S & 16	-16	16
18	-18	18
20	-20	20
22	-22	22
24	-24	24
28	-28	28
32	-32	32

3–69. CANNON MS CLASS B CONNECTORS. Cannon Class B connectors are supplied with a split shell held together by a shell assembly nut as shown in figure 3–18. Cannon Class B connectors are installed as follows:

a. Remove split shell by loosening shell assembly nut. Do not remove coupling nut from plug body.

b. If all contacts are size 12 or smaller, no further disassembly is required. For removal of larger contacts see 3–24.

c. Install the following items on wire bundle in listed order as shown in figure 3–63.

1. Cable clamp with loosened saddle.

2. AN3420 telescoping bushing (at least one-extra telescoping sections are added if necessary).

d. Slide insulating sleeves over each wire in bundle. Sleeves should be placed one inch back from wire ends to avoid burning during soldering operation. See 3–40 for data about insulating sleeves.

e. Solder wires to contacts using processes described in 3–42 through 3–47.

f. Clean connections and slide insulating sleeves over contacts until they bottom against insert.

g. Tie sleeves to wires using nylon braid as shown in figure 3–40.

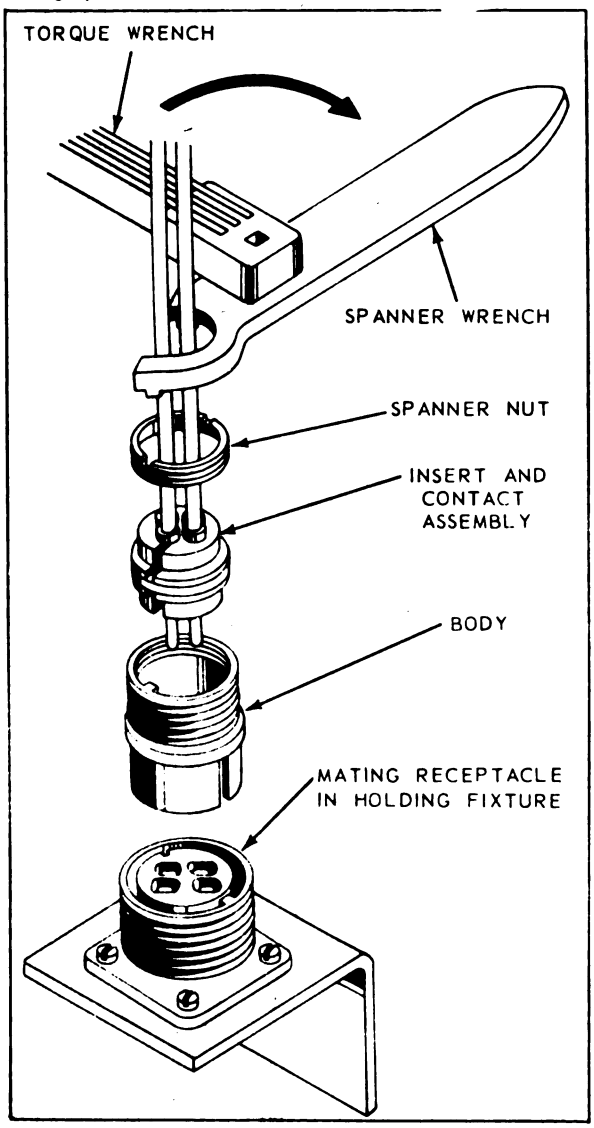


Figure 3–62. Torque Wrench Used on Bendix Fireproof Connector

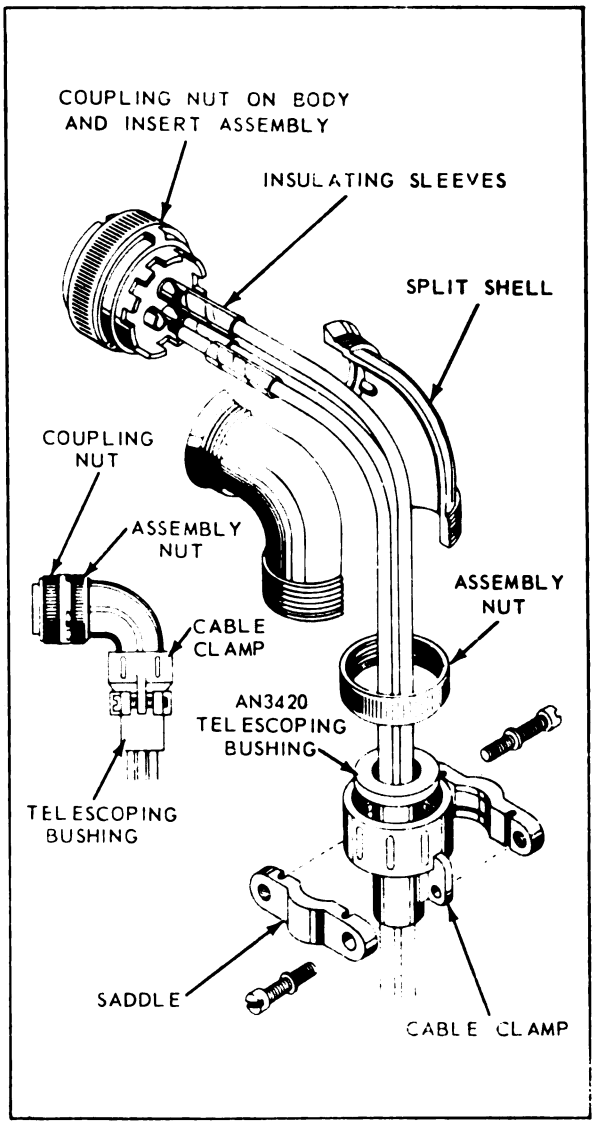


Figure 3–63. Installation of Cannon Class B Connector

h. Reassemble split shell. Be careful not to pinch wires. Rotate and lock angle back shell in proper position.

i. Install cable clamp as described in 3–54.

3–70. CANNON MS CLASS C CONNECTORS. Cannon MS Class C connectors are supplied only as receptacles MS3100C and MS3102C.

CAUTION

Do not remove Class C inserts or contacts. Removal will break the pressure seal.

Install Cannon MS 3100C as follows: (See figure 3–64)

a. Remove back shell by unscrewing from body. Slide MS3057A cable clamp, AN 3420 telescoping bushing and back shell on the wire bundle in that order.

b. Slide insulating sleeves over each wire in bundle. Sleeves should be placed one inch back from wire ends to avoid burning during soldering operation. See 3–40 for data about insulating sleeves.

c. Solder wires to contacts using methods described in 3–42 through 3–47.

d. Clean connections and slide insulating sleeves over contacts until they butt against the insert.

e. Tie sleeves to wires using nylon braid as shown in figure 3–40.

f. Slide back shell down over wire bundle and tighten to body. Use strap wrench to tighten back shell 1/8 turn beyond hand tight.

g. Install cable clamp as described in 3–54. Install Cannon MS3102C in the same manner as Cannon MS3100C except omit steps a and f.

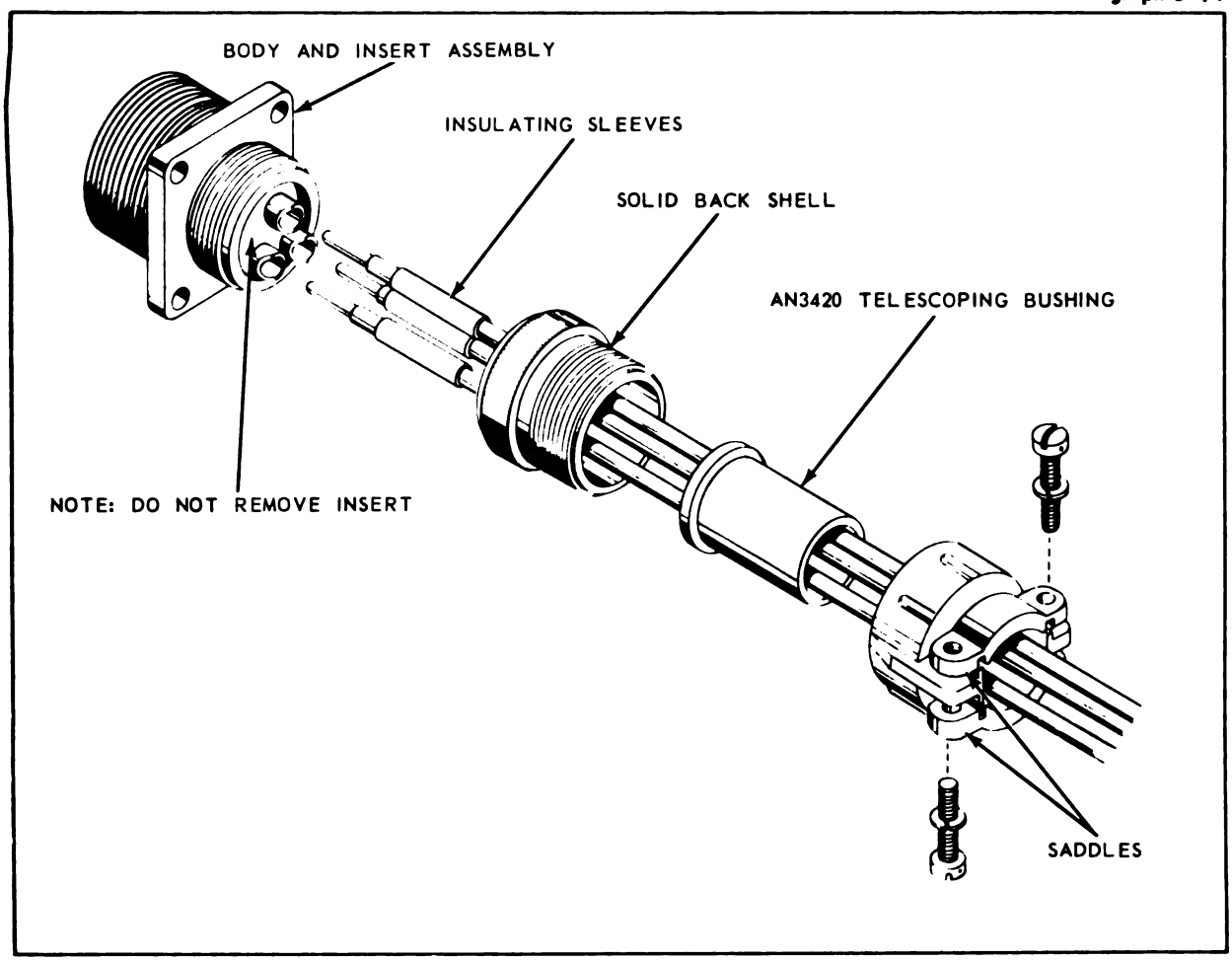


Figure 3–64. Installation of Cannon Class C Connector

3–71. CANNON MS CLASS E CONNECTORS. Install Cannon Class E connectors as follows: (See figure 3–65)

a. Unscrew back shell. Do not pull AN 3420 bushings out of back shell. Loosen saddles but do not remove them from back shell.

b. Slide back shell and bushing assembly over wire bundle.

c. Thread pre-tinned wires through grommet follower and through grommet. Note relationship of grommet follower and grommet in figure 3–65.

CAUTION

Insert proper wires in holes of grommet and grommet follower. These are coded to match markings on back of insert.

Use alcohol as a lubricant if necessary. After wires are threaded through grommet, use air blast to dry alcohol.

Note

Do not install insulating sleeves on wires.

d. Solder wires to contacts as described in 3–42 through 3–47. If contacts are larger than number 12 size, they are removed as described in 3–24.

e. Reinstall large contacts by pushing them through rear of insert until seated. (See figure 3–57.) Use alcohol as a lubricant, if necessary. Install each contact, when cool, before proceeding to solder next contact. This will help avoid erros. Use a bakelite screw-driver to aid in seating contacts.

f. Slide grommet down over wire bundle.

CAUTION

Pull lightly on each wire as grommet is seated to prevent wires folding between insert and grommet.

g. Slide grommet follower down over wire bundle. Use same caution as in step f. (See figure 3–66.)

h. Slide back shell and bushing assembly over wire bundle and hand tighten to body. Use strap wrench to tighten back shell until it bottoms.

i. Tighten saddle screws until 1/16" clearance remains between each saddle and mounting tab of back shell.

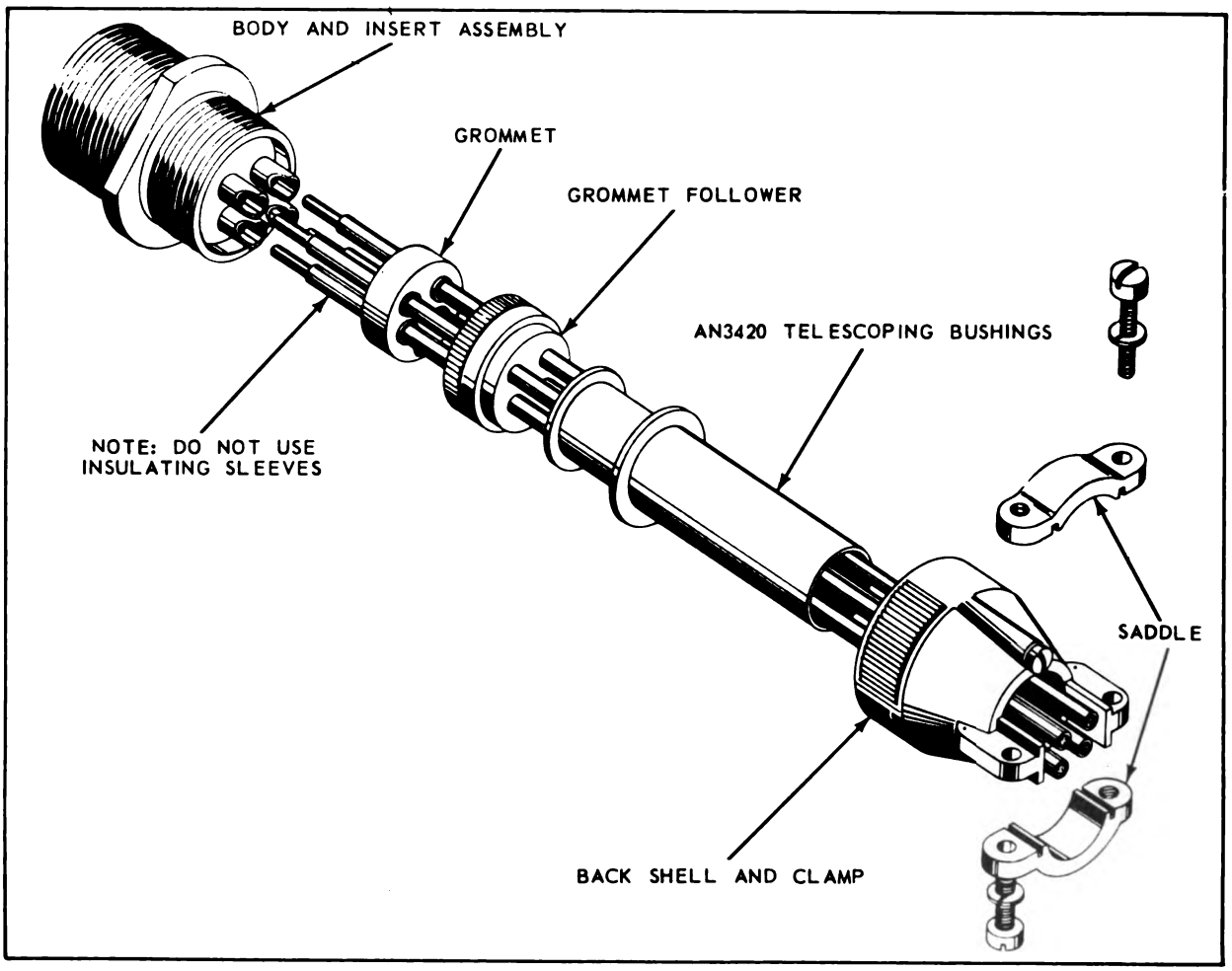


Figure 3–65. Installation of Cannon Class E Connector

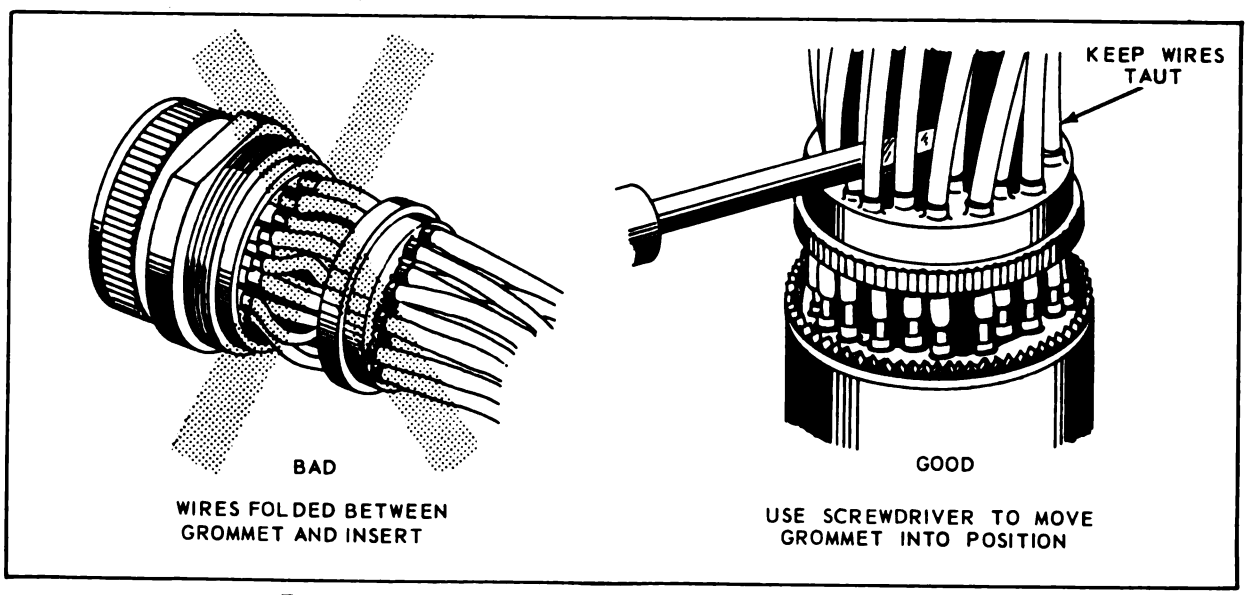


Figure 3–66. Cannon Class E Connector – Grommet Installation

3–72. CANNON MS CLASS R CONNECTORS. The installation of Cannon Class R connectors is the same as that for Cannon Class E connectors.

3–73. CANNON FIREPROFF CONNECTORS. Cannon fireproof connectors have crimp type contacts to withstand high temperature operating requirements. Installation is as follows: (See figure 3–67)

a. Release back shell by removing four holding screws. Do not remove coupling nut from plug body.
b. Use retaining ring pliers to remove internal retaining ring.
c. Tap connector body in palm of hand to remove inserts. Separate inserts to release contacts.
d. Carefully plull retaining clips from contacts. Do not lose clips.
e. Install the following items on wire bundle in listed order:

1. Back shell, with conduit if required.
2. Retaining ring.

f. Silver solder, or crimp wires into contacts using any of the methods described in section V.
g. Slide contacts through rear insert. Be careful to get each contact into its proper location by observing the identification letters on the insert.
h. Reinstall the retaining clips to lock contacts into inserts.
i. Push front insert over contacts. Observe identification letters to assure proper location of contacts.
j. Examine contact and insert assembly to see that insert halves butt, and then slide assembly into body.
k. Reinstall retaining ring.
l. Tighten back shell by replacing four holding screws.
m. Tighten conduit coupling nut or other required fitting. Use strap wrench to tighten 1/8 turn beyond hand tight.

3–74. MINIATURE MS CONNECTORS WITH SOLDER TYPE CONTACTS. Miniature MS connectors Class E and F are installed as follows:

a. Remove retaining nut by unscrewing it from the body shell, and slide the nut over the wire bundle.
b. Slide tapered sleeve, (grommet follower) over wire bundle.
c. Thread wires through the proper grommet holes.
d. Strip and tin wires following the procedures outlined in section II. Strip insulation 1/4 inch for sizes 12 and 16 contacts; strip insulation 1/8 inch for size 20 contacts.
e. Insert tinned wire into the solder cup of the contact. Apply heat with a resistance soldering unto as shown in figure 3–31; a soldering unit with a foot switch is recommended. Heat until solder is liquified; apply more solder if necessary. When solder is liquid, press the foot switch to turn off the heat, but do not remove the resistance unit probes until the solder has solidified. Do not move the joint until the solder has cooled.
f. Slide the grommet forward over the solder cups of the contact against the fact of the insert.
g. Slide the tapered sleeve (grommet follower) over the end of the grommet.
h. Bring the retaining nut forward and tighten it to the body shell.

CAUTION

Do not remove inserts from these connectors.

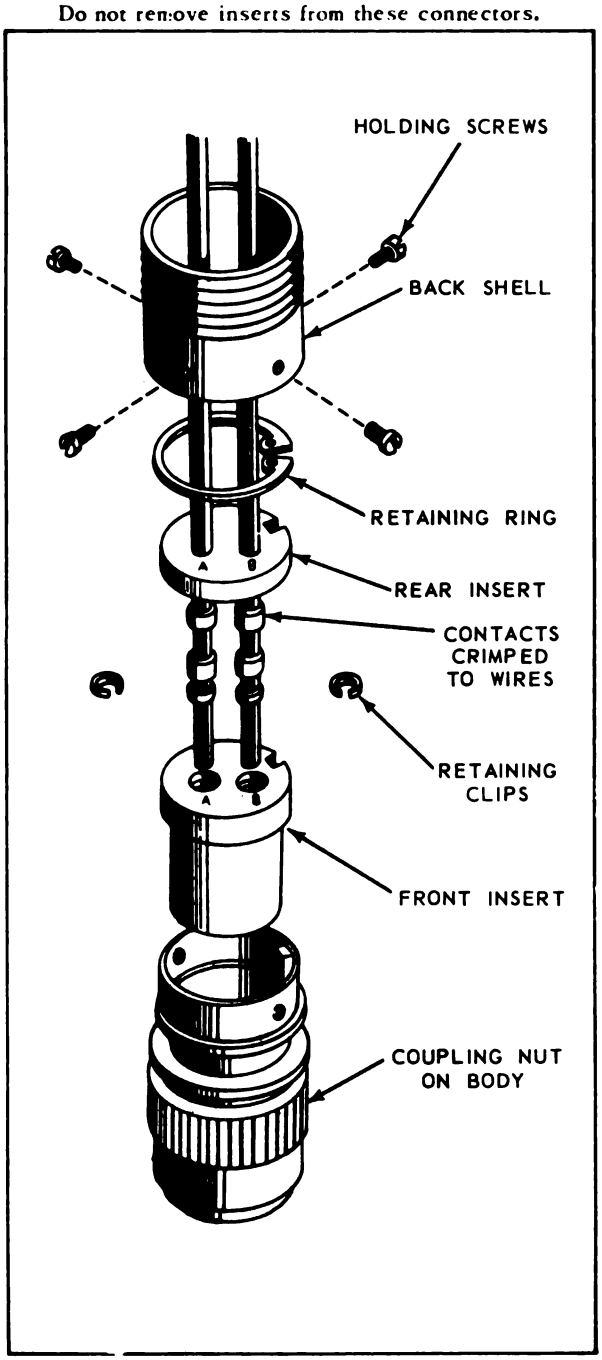


Figure 3–67. Installation of Cannon Fireproof Connector

3–75. Install Class P miniature MS connectors with solder type contacts as follows:

a. Remove potting mold and retaining ring from body shell, and slide over wire bundle.
b. Prepare wires and solder to contacts as described in 3–74, steps d and e.
c. Slide retaining ring and potting mold down wire bundle, and screw to body shell.

Note

Make sure that retaining ring is fully tightened. A loosely coupled ring affects the bayonet action of the coupling ring.

d. Pot connector as described in 3–62.

3–76. Class H miniature MS connectors are not disassembled for soldering. Prepare wires and solder to contacts as described in 3–74, steps d and e.

3–77. MINIATURE MS CONNECTORS WITH REMOVABLE CRIMP-TYPE CONTACTS. These connectors are received from the manufacturer with the contacts separately packaged, so that the wires can be crimped to the contacts with a crimping tool before they are assembled into the connector insert.

3–78. HAND CRIMPING TOOLS FOR CONNECTOR CONTACTS. (See figure 3–68) The Military Standard tool for crimping electric connector contacts is MS3191. It is a hand operated tool, cycle controlled by means of a ratchet which will not release until the crimping cycle has been completed. The tool has a separate positioner for each contact size, color coded as follows:

Contact Size No. 20 – Red
No. 16 – Blue
No. 12 – Yellow

Use this tool for assembling wires to crimp type removable contacts of all Military Standard miniature connectors.

CAUTION

Do not disassemble this tool. Do not tighten or loosen nuts on back of tool.

3–79. MS3191-1 CRIMPING TOOL. As shown in figure 3–68a, this tool has one contact positioner installed in the tool, and the other two stored in a cavity in the tool handle. The three contact sizes, and the wire sizes each contact will accommodate are marked and color coded on a data plate on the face of the tool.

3–80. MS3191-3 CRIMPING TOOL. In this tool the color coded positioners are fixed in a rotating turret contained in the tool head. (See figure 3–68b). Wire sizes are marked on a selector plate on the face of the tool. Correct indentor closure for wire size being used is set by moving thumb button pointer to desired wire size.

Note

Either MS3191-1 or MS3191-3 may be used to crimp contacts shown on Military Standard drawing MS3191.

3–81. TOOL INSPECTION. The standard MS3191 crimping tool is checked for proper adjustment of the crimping jaws by means of the appropriate MS3196-3 gage. Do this before each series of crimping operations.

Note

If tool fails to gage correctly, or if the ratchet becomes inoperative, return the tool for repair.

3–82. INSPECTING MS3191-1 CRIMPING TOOL. This tool is gaged separately for each positioner. The procedure is as follows:

a. Make sure the positioner is locked in place.
b. Select the proper gage for the positioner being used.
c. With the tool fully closed, insert the GO gage through the positioner and into the crimping dies. The GO gage should enter the positioner and dies freely so that the gage handle seats firmly on the top of the positioner. (See figure 3–69)
d. The NO-GO gage should not be able to enter into the crimping dies, and the gage handle does not seat on the positioner.

CAUTION

Do not crimp down on the gage pin as this will prevent the tool from cycling to ratchet release position.

3–83. INSPECTING MS3191-3 CRIMPING TOOL. Only the No. 20 wire size indentor setting is gaged for this tool. The procedure is as follows:

a. Slide the thumb button until the pointer is in line with the No. 20 wire size on the selector plate. (Refer to figure 3–68b).
b. Close the tool handles to fully closed position.
c. The GO pin of MS3196-20 gage should pass freely through the indentor tips.
d. The NO-GO gage pin should not pass between indentor tips.

CAUTION

Do not crimp down on the gage pin as this will damage the indentors.

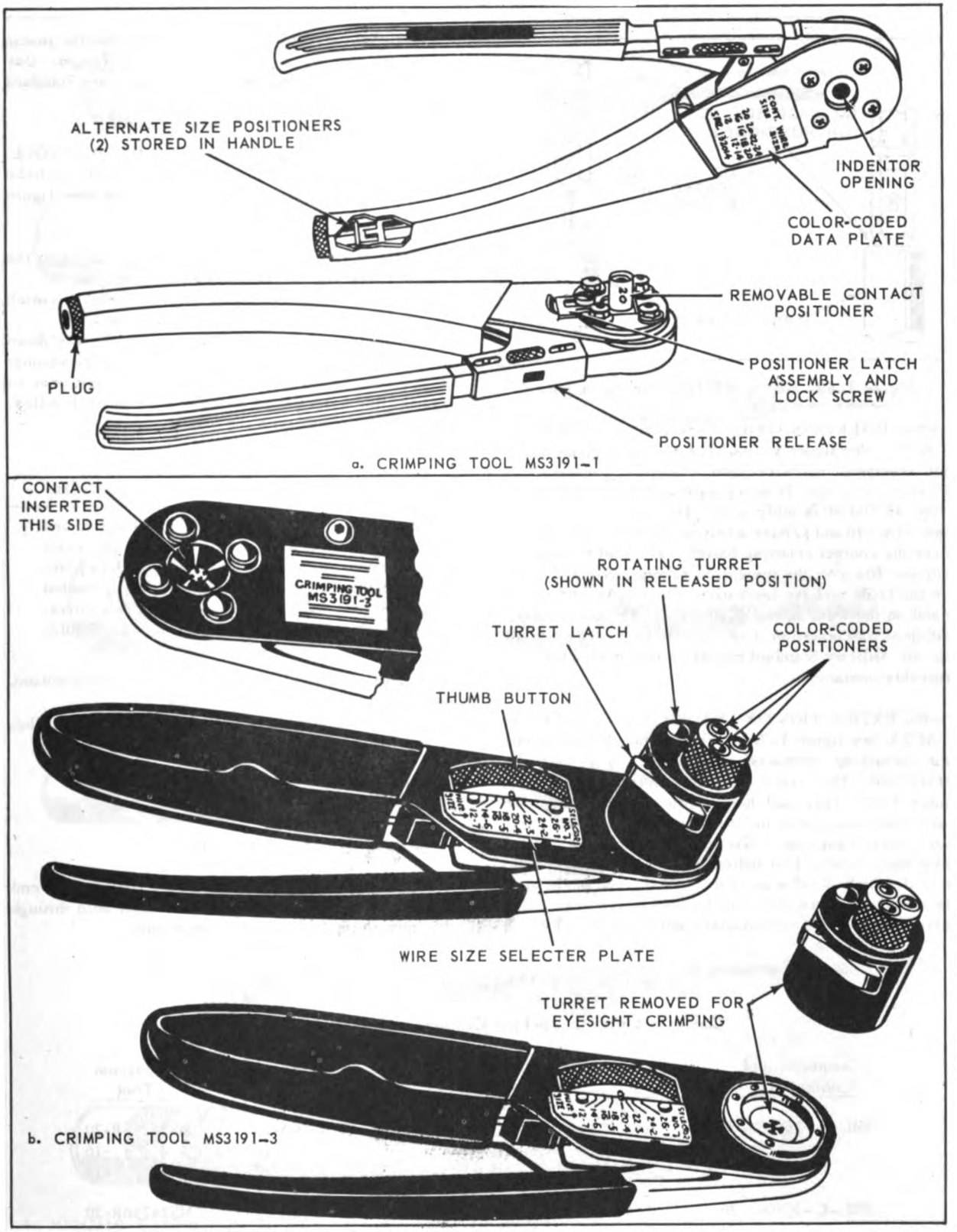


Figure 3-68. MS3191 Standard Crimping Tools

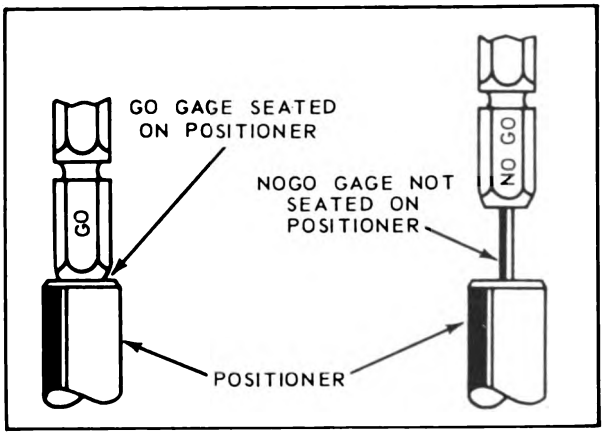


Figure 3-69. Gaging MS3191-1 Crimping Tool

3-84. INSERTION TOOLS FOR CRIMP TYPE CONTACTS. See figure 3-70a. The Military Standard tool for inserting contacts into connector inserts is MS24256A. There is a separate tool for each contact size as listed in table 3-17. Inserting tools for contact sizes 16 and 12 have a hollow lip which fits snugly over the contact crimping barrel. The tool for size 20 contact fits over the insulation support. Contact sizes 16 and 12 do not have insulation support. An indicating band on the working end of the tool determines correct depth of tool insertion. Use this tool to insert contacts in all Military Standard miniature connectors with removable contacts.

3-85. EXTRACTION TOOLS FOR CRIMP TYPE CONTACTS. See figure 3-70b. The Military Standard tool for extracting contacts from connector inserts is MS24256R. The sizes for each contact are listed in table 3-17. This tool has a hollow cylindrical probe which fits snugly over the pin or socket end of the contact, and releases the insert retention clip when pushed over the contact. Two indicating bands determine correct depth; the band nearest the working end of the tool is for pin contacts, the other for socket contacts. The extraction tool has a thrust assist collar (or slide) which is pushed forward to eject the contact from the insert retention clip by means of an internal plunger. Use this tool tc remove contacts from all Military Standard miniature connectors with removable contacts.

3-86. CRIMPING PROCEDURE FOR MS3191-1 TOOL. The procedure for assembling wires to contacts with the MS3191-1 hand crimping tool is as follows: (See figure 3-71)

a. Open the crimping tool by exerting pressure on the handles until the ratchet releases.

b. Loosen the latch locking screw, and pull the latch to the open position, (refer to figure 3-68a).

c. Pull the positioner release all the way down against spring pressure and insert the correct positioner for the contact being crimped. Insert the positioner so that the flat on its flange mates with flat on the handles, and flange is flush with the handle.

Note

Positioners are stored in the tool handle, and are stamped with contact number, and color coded to match the color code on the data plate on the face of the tool. Pull the spring loaded plug to remove (or replace) the positioners. Store positioners not being used in handle.

d. Push the positioner latch to the closed position, and tighten the latch locking screw.

e. Strip the wire using any of the methods described in section II. Stripping lengths are:

Contact size 20 - .157 to .186

Contact size 16 - .250 to .284

Contact size 12 - .250 to .284

f. Insert the stripped wire into the contact until end shows through inspection hole and insert both through the indentor opening into the positioner.

TABLE 3-17

Connectors With Crimp-Type Contacts and Assembly Tools

Connector and Contact Size		Color Code	Crimping Tool	Insertion Tool	Extraction Tool
MIL-C-26482:	20	Red	MS3191-1 or 3	MS24256A-20	MS24256R-20
	16	Blue	MS3191-1 or 3	-16	-16
	12	Yellow	MS3191-1 or 3	-12	-12
MIL-C-26500:	20	Red	MS3191-1 or 3	MS24256A-20	MS24256R-20
	16	Blue	MS3191-1 or 3	-16	-16
	12	Yellow	MS3191-1 or 3	-12	-12

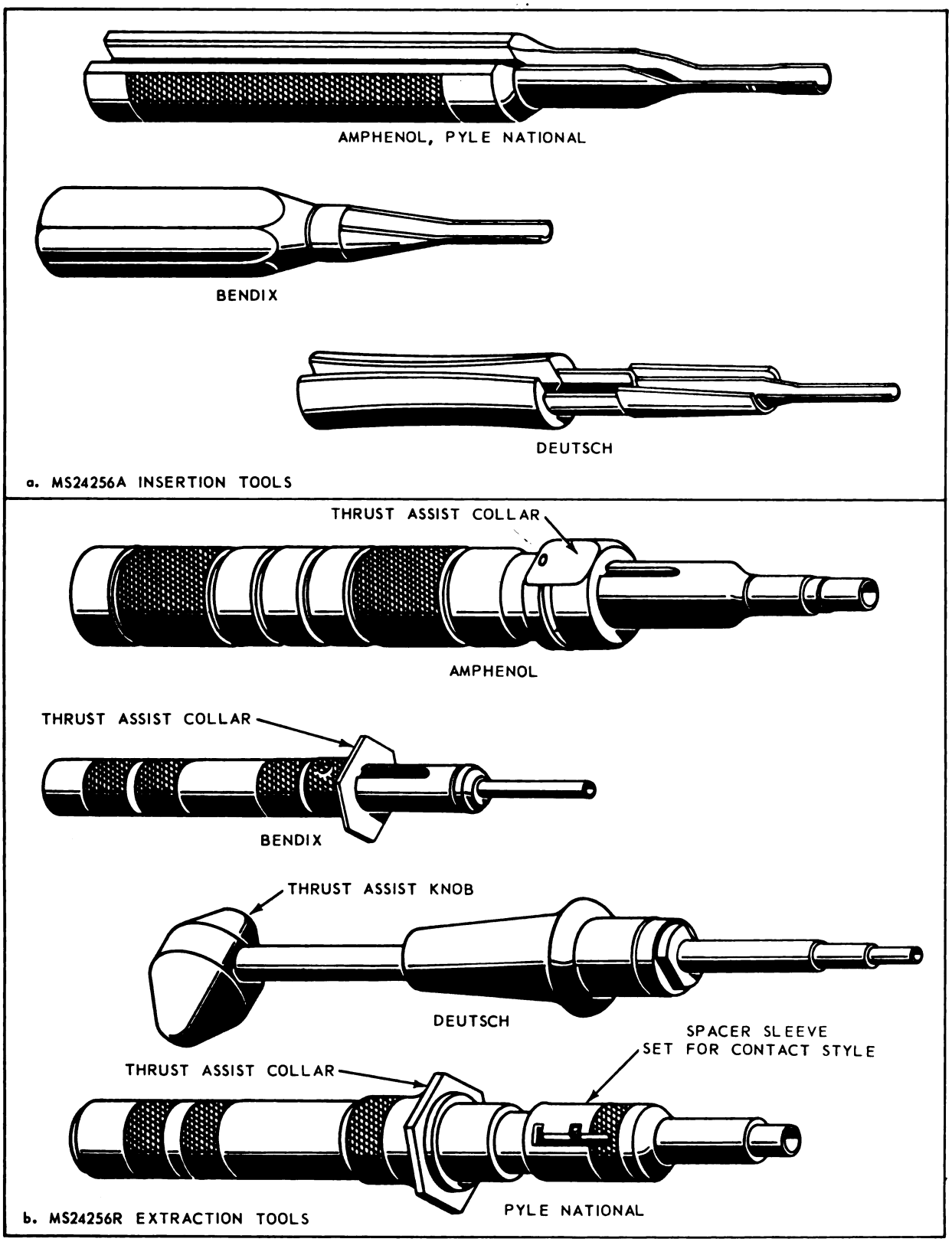


Figure 3–70. Insertion and Extraction Tools for Crimp-Type Contacts

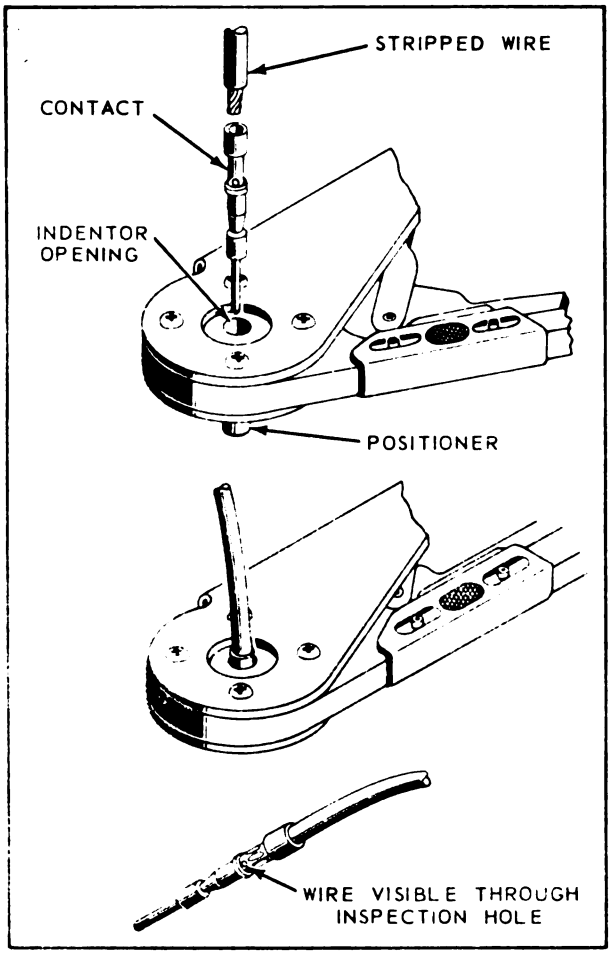


Figure 3-71. Assembling Wires to Crimp-Type Contacts

Note

When crimping size 20 contacts, make sure that insulation extends into insulation support of contact.

g. Squeeze the tool handles with one firm stroke until the positive stop is reached. The ratchet will then release and the tool will open. Remove the crimped contact and wire.

3-87. CRIMPING PRCCEDURE FOR MS3191-3 TOOL. The procedure for assembling wires to contacts with the MS3191-3 hand crimping tool is as follows:

a. Release turret by depressing turret latch with thumb, and rotate turret until correct positioner for contact being crimped lines up with index line on head assembly. (Refer to figure 3-68b).

b. Push turret down into latched position.

c. Slide thumb button until pointer is in line with wire size being used, as marked on selector plate.

d. Strip wire as described in 3-86e.

e. Insert the stripped wire into the contact until end shows through assembly hole. Insert wire and contact through the indentor opening into the positioner.

Note

When crimping size 20 contacts, make sure that insulation extends into insulation support of contact.

f. Squeeze the tool handles as far as they will go. The ratchet will then release and the tool will open.

g. Remove crimped contact and inspect.

Note

Provision is made for safety-wire locking both head and thumb button for production runs of same size contact and wire.

3-88. EYESIGHT CRIMPING. Short contacts may be crimped in the MS3191-4 tool (MS3191-3 with the turret removed.) The procedure is as follows:

a. Release the turret by depressing the turret latch.

b. Loosen the two retainer screws with the 1/8 Allen wrench supplied with the tool. Remove the head from the tool frame.

c. Slide the thumb button until the pointer lines up with the wire size to be crimped.

d. Insert the contact into the tool, and slowly close the handles, at the same time positioning the contact so the indentors will crimp midway on the crimp barrel.

e. Hold the contact lightly with the indentor tips, and insert the stripped wire into the contact.

f. Make sure the wire is bottomed in the contact, and close the handles all the way.

g. Remove the crimped contact, and inspect.

h. Check to make sure that the wire is visible in the inspection hole.

3-89. ASSEMBLING WIRED CONTACTS INTO CONNECTOR. Insert the crimped contact into the connector as follows: (See figure 3-72)

a. Slide rear accessories back onto wire bundle.

b. Select the correct insertion tool from table 3-17. Insert the crimped end of the contact into the hollow end of the insertion tool, and lay the wire into the slot in the tool handle.

c. Guide the contact into the correctly numbered grommet hole in the rear face of the insert, and feed the contact carefully into the hole.

d. Push the tool straight in at right angles to the grommet surface, until the contact is fully seated. At the indicator band on the tool enters the grommet hole the contact retention clip will snap into place on the contact with a slight audible click.

e. Withdraw the tool, keeping it perpendicular to the grommet face.

f. Fill all unused holes with sealing plugs of appropriate size

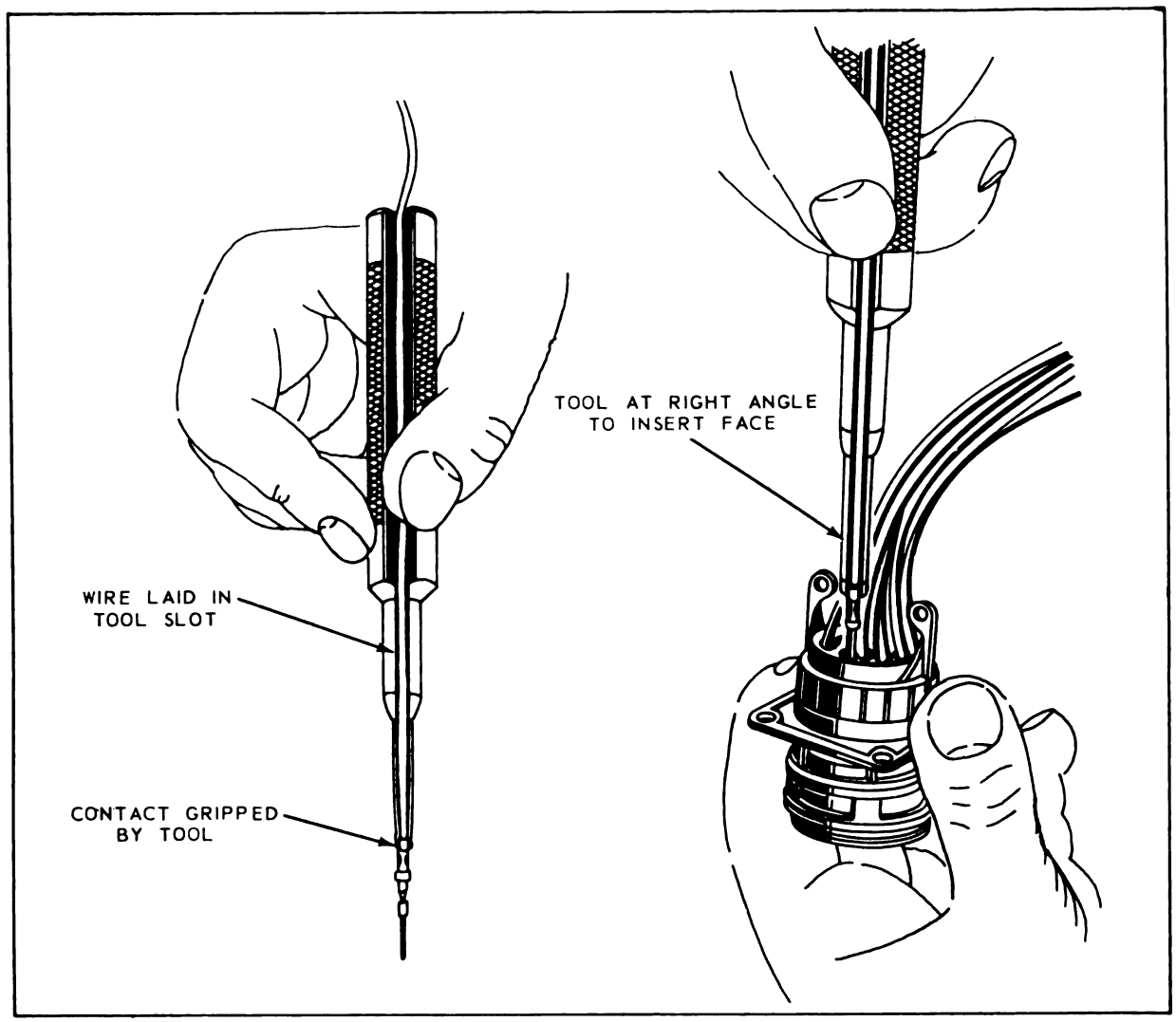


Figure 3–72. Assembling Wired Contacts Into Connector

CAUTION

Do not attempt to reseat a contact once the insertion tool has been removed. Remove contact and start over again with contact barrel properly located in tool. Failure to follow this precaution will cause insertion tool to shear barrel while inside grommet. Sharp edge of sheared material will cut through grommet web and cause short circuit.

3–90. ALTERNATE CONTACT ASSEMBLY PROCEDURE. If desired, the following procedure may be used to insert wired contacts into the connector:

a. Push the wired contact carefully into the correct grommet hole. Do not push all the way in.

b. Slide the insertion tool over the contact barrel. When installing a size 20 contact, the tool internal shoulder will butt against the rear of the contact insulation support. When installing size 16 or 12 contacts the tool tip will butt against the contact shoulder.

c. Complete the procedure by following steps d, e and f of 3–89. Observe caution note of 3–89.

3–91. REMOVING CONTACTS FROM CONNECTOR. Remove contacts from the connector as follows: (See figure 3–73)

a. Select the correct extraction tool for the contact to be removed from table 3–17.

b. Slide rear accessories back on the wire bundle.

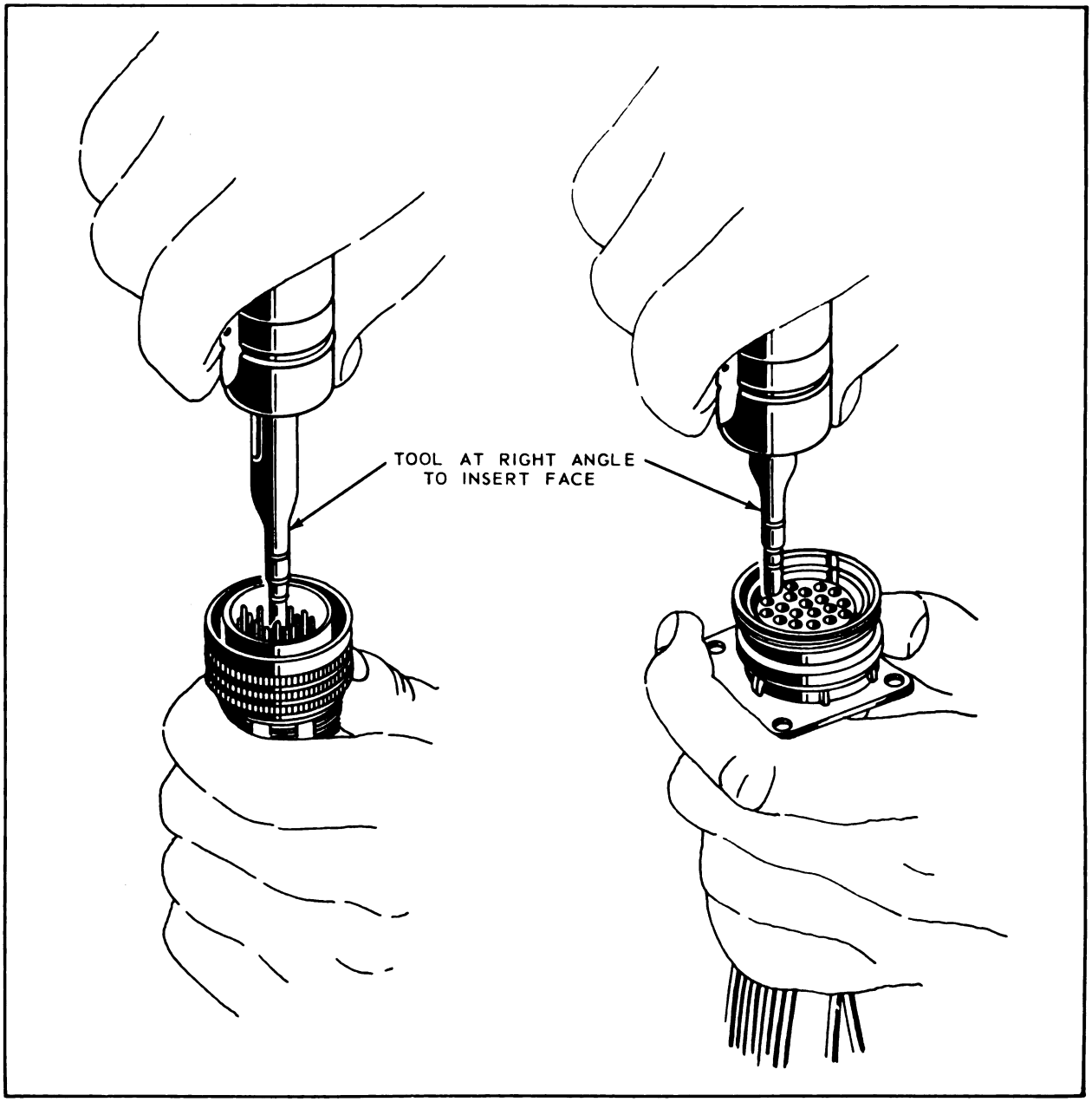


Figure 3–73. Removing Crimp-Type Contacts from Connector

c. Working from the front or mating end of the connector, slip the hollow end of the extraction tool over the contact, with the tool parallel to the contact, and squarely perpendicular to the insert face.

Note

The Pyle-National extraction tool has a spacer sleeve with positions for either male or female contacts. Set to correct position before installing tool on contact. Refer to figure 3–70b.

d. Push the tool toward the rear of the connector with a firm steady push until the tool comes to a positive stop and bottoms in the insert hole. A slight rotation of the tool may aid the tool insertion.

e. Push the thrust assist collar or slide forward as far as it will go.

f. Withdraw the tool from the contact, keeping the tool perpendicular to the insert face.

g. Remove the contact from the back of the connector.

CAUTION

Make sure the extraction tool is always exactly aligned with the contact to avoid damage to the contact or to the insert.

3-92. NON-STANDARD CONNECTORS WITH REMOVABLE CRIMP-TYPE CONTACTS. In addition to the MS connectors described in 3-6 and 3-11, there are four series of non-standard connectors also having removable crimp-type contacts. These are assembled in the same way as the corresponding MS standard connectors, except that tools used are made by the manufacturers of the connectors. These non-standard connectors are as follows:

a. Amphenol #69 series. Similar to the large standard MS connectors, and mating with them. Applicable tools are listed in table 3-18.

TABLE 3-18

Installation Tools for Crimp-Type Contacts - Amphenol #69 Series

Contact Size	Crimping Tool	Insertion Tool	Extraction Tool
16	MS3191	294 - 39	294 - 40
12			

b. Bendix #10-214000 Series. Similar to the large standard MS connectors, and mating with them. Crimping tools are listed in table 3-19.

TABLE 3-19

Crimping Tools for Crimp-type Contacts Bendix #10 - 214000 Series

Contact Size	Crimping Tool	Locator
16 M	11-6941 - 1	11-6932 - 1
16 M long	11-6941 - 1	11-6932 - 2
12	11-6941 - 1	11-6932 - 3

CAUTION

Size 16 pin and socket contacts are available in long and short lengths. Care should be exercised to prevent mismating one to the other.

c. Cannon EXA Series. Similar to the AN type Class R connectors and mating with them. Tools listed in table 3-17 are used for assembling these connectors.

d. Bendix CE series. A miniature series of connectors, available in shell styles similar to those of MS miniature connectors made by Bendix. Applicable tools are listed in table 3-20.

Installation of Bendix "CE" series connectors is as follows:

1. Strip the wire insulation to 1/8 inch for size 20 contacts, and to 1/4 inch for size 16 contacts.
2. Install the correct positioner from table 3-20 into the crimping tool and crimp the contact to the wire as described in 3-86.
3. To insert contacts into the connector select the correct insertion tool from table 3-20. Slide rear accessories on the wire bundle. Grasp the crimped end of the contacts with the pliers so that the shoulder in the tip of the tool butts against the end of the wire well.
4. Align the contact with the hole in the rear face of the insert and push forward in line with the hole until the contact is felt to snap in position. A slight increase in resistance may be noticed just before the contact reaches its seated position.

Note

The contact may be positioned by hand in the corresponding hole in the grommet before final seating with the insertion tool, to insure proper alignment of the contact during insertion.

5. Remove the insertion tool tips from the grommet by releasing the holding pressure on the handles and pulling straight to the rear.
6. Fill all unused insert holes with grommet sealing plugs of appropriate size.
7. To remove contacts, push contacts from the front face of the connector through the grommet using the correct tool from table 3-20.

TABLE 3-20

Installation Tools for Crimp Type Contacts-Bendix CE Series

Contact Size	Crimping Tool	Positioner	Insertion Tool	Removal Tool* Pins	Removal Tool* Sockets
20	MS3191 - 1	11-7771 - 5	11-6782	11-6783	11-6784
16	MS3191 - 1	11-7771 - 6	11-6781	11-3697	11-3698

*With Handle 11-6911 or 11-3699

3–93. CANNON DPD CONNECTORS. Cannon DPD connectors have rectangular shells. Their main use is for rack and panel plug-in assemblies. These connectors are not MS but they have many applications in military aircraft where it is desirable to combine coaxial cable disconnects with general wiring disconnects in one unit. Installation is as follows: (See figure 3–74)

a. Thread bushings (AN 3420) if required, into end bell from inside so that flange of bushing rests flush against inside of rear wall of end bell.

b. Slide end bell assembly on wire bundle.

Note

Steps c through h are only for connectors which have coaxial contacts.

c. Remove stop nuts on rear of shell to free coaxial contact retaining clips. Coaxial contacts are removed from rear of insert. (See figure 3–75)

d. Strip and prepare coaxial cable following procedures given in section IV, paragraphs 4–17 through 4–25. See table 3–21 for stripping dimensions.

e. Remove solder pot cover from contact by prying out with knife.

f. Insert cable and solder center conductor to contact. The dielectric should butt against contact solder pot. Remove flux with Stoddard's solvent.

g. Replace solder pot cover and solder shield to ferrule.

h. Remove flux with solvent. Do not allow solvent to flow under solder pot cover.

i. Solder general purpose wires to remaining contacts in insert. Use procedures described in 3-42 through 3-47.

j. Clean rear of insert by brushing with Stoddard's solvent. If rear of connector is to be potted, follow cleaning with a methylene chloride wash as described in 3–62e.

CAUTION

Methylene chloride vapors are toxic.

k. Reinstall coaxial contacts and replace retaining clips. Replace stop nuts to hold insert and coaxial contacts in shell.

l. Slide end bell into position and mount to flange of shell.

Note

Step m and n apply only to connectors which are to be potted

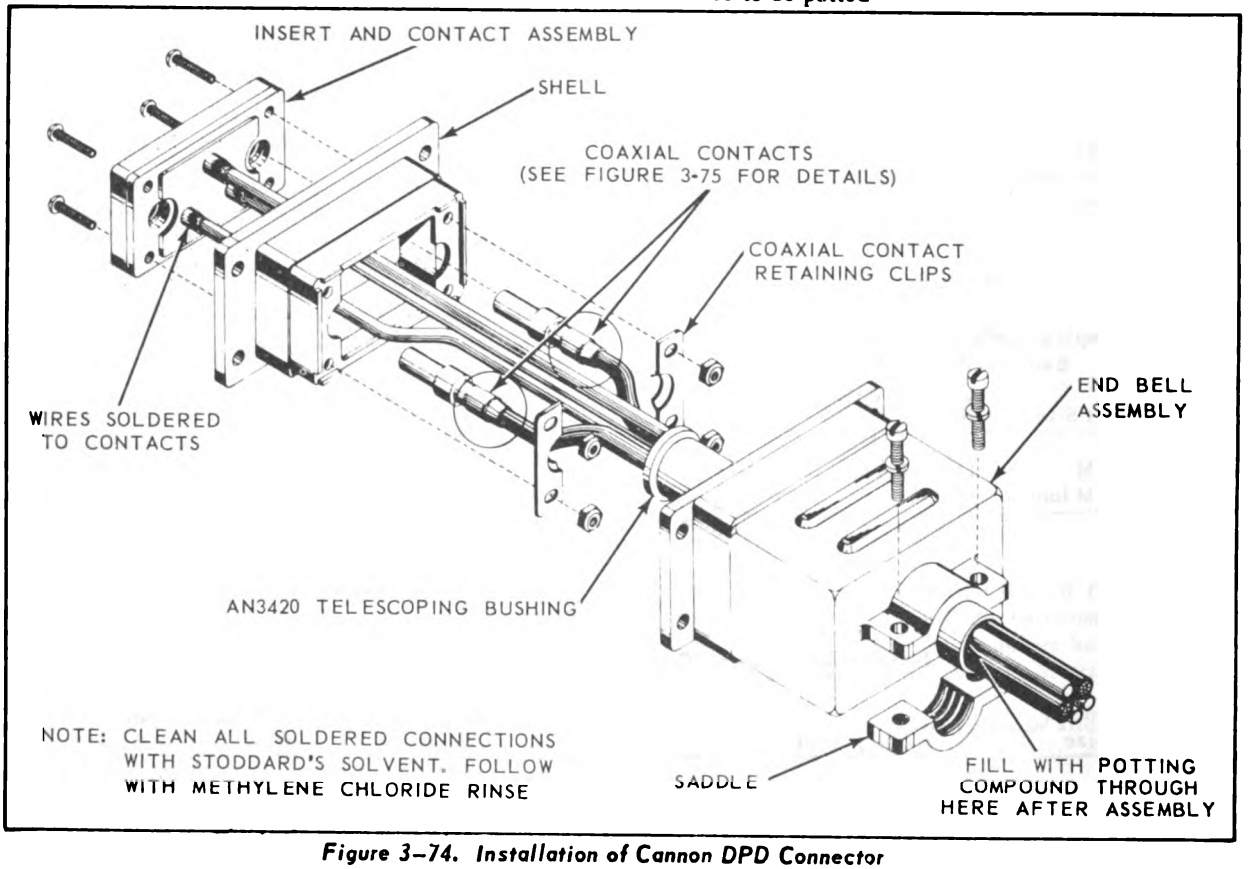


Figure 3–74. Installation of Cannon DPD Connector

TABLE 3-21

Stripping Dimensions for Coaxial Cable

Contact Type	Cable	Strip Length (inches) A	B	C
Straight	RG-58/U	1/8	15/32	5/8
	RG-59/U	1/8	15/32	5/8
	RG-62/U	1/8	15/32	5/8
90° Angle	RG-58/U	3/16	15/32	19/32
	RG-59/U	3/16	15/32	19/32
	RG-62/U	3/16	15/32	19/32

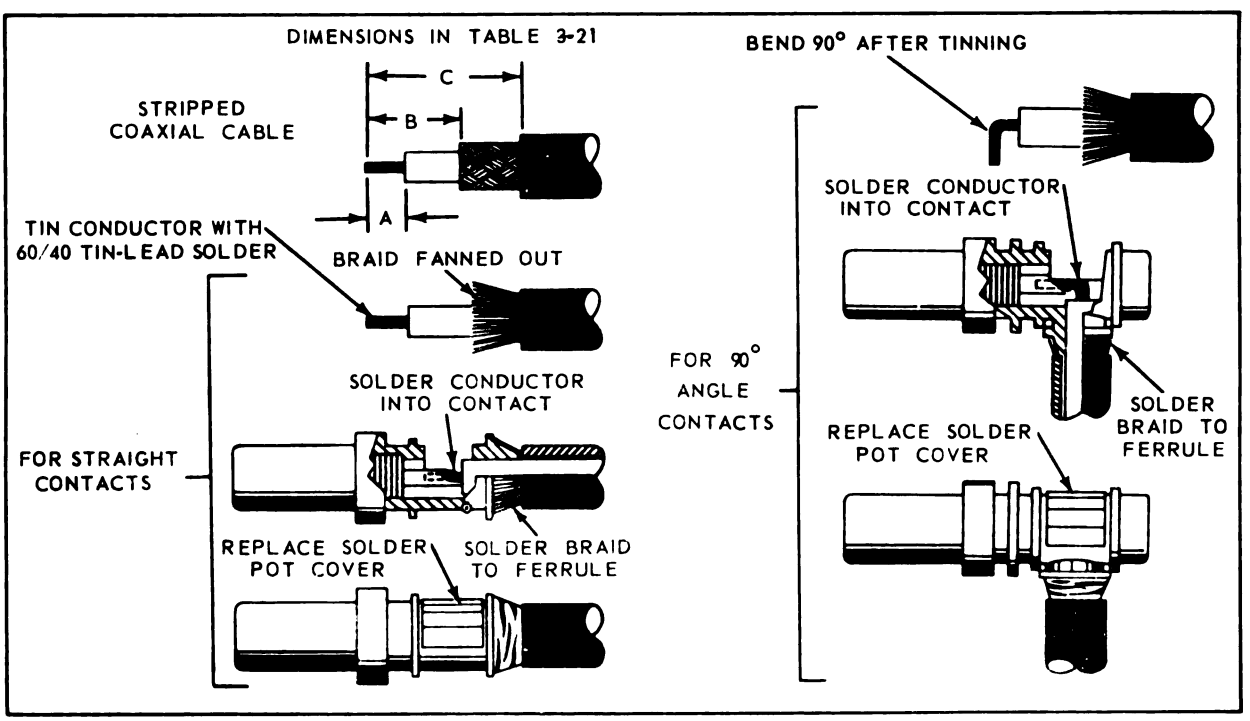


Figure 3-75. Soldering Coaxial Cable to Contacts for DPD Connector

m. Push nozzle of potting gun down through telescoping bushing (AN3420) and fill connector back with potting compound. Fill slowly to be sure all air is expelled.

n. Allow potting compound to cure for 24 hours at room temperature (70°F to 75°F).

o. Tighten saddle to compress telescoping bushing (AN3420).

3-94. SUBMINIATURE CONNECTORS. Cannon connectors, UCS, UDS, and UES are simple subminiatures. The disassembly is described in 3-32. Solder wires carefully to the contacts using a pencil type resistance soldering iron as shown in figure 3-31, and described in 3-43b. Clean off excess flux, and reassemble connector by reversing the disassembly procedure. Potting compound is forced through the back shell to provide a moisture and vibration proof seal. Directions for potting are given in 3-62.

3-95. MINIATURE RECTANGULAR CONNECTORS. These connectors consist of a one piece body into which the contacts are molded. There is no back shell, and no disassembly is required. A hood with cable clamp is used on either plug or receptacle to provide protection and support for the wires. Install the hood over the wire bundle, and solder wires to contacts using a resistance soldering unit. After the solder connection has cooled attach the hood to the connector with screws of the proper size. These connectors are also available with taper pin contacts. See section VI for taper pin installation instructions.

3-96. SHIELD AND MULTIPLE CONNECTIONS.

3-97. CONNECTING SINGLE SHIELDED WIRE TO MS AND POTTED CONNECTORS. Terminate single shielded wires as described in section II paragraph 2-59. For connection to Class A, B, C or K connectors, shield must end inside back shell as shown in figure 3-76. For connection to Class E, Class R or potted connectors shield must end outside seal. Crimp pigtail into terminal lug and ground to screw as shown in figure 3-77, or use permanent splice to join pigtail to short length of AN wire which is then terminated inside connector to contact in regular manner, as shown in figure 3-78.

3-98. CONNECTING SEVERAL SHIELDED WIRES TO MS AND POTTED CONNECTORS. Potted connectors which contain shielded wires and all other connectors which have many shields must terminate shields outside the connector. The procedure is as follows:

a. Form pigtail from shield outside connector area. See section II paragraph 2-63.

1. For potted connector, pigtail should start 1" from end of wire.

2. For other connectors, pigtail should start far enough back to remain outside cable clamp.

b. Solder each wire to its contacts.

c. Crimp pigtails together into one end of permanent splice.

d. Crimp single wire, (doubled if necessary - see section V) into other end of permanent splice.

e. Slide insulating sleeve over splice and tie in place as shown in figure 3-78.

f. Solder single wire to proper contact in connector as shown in figure 3-78.

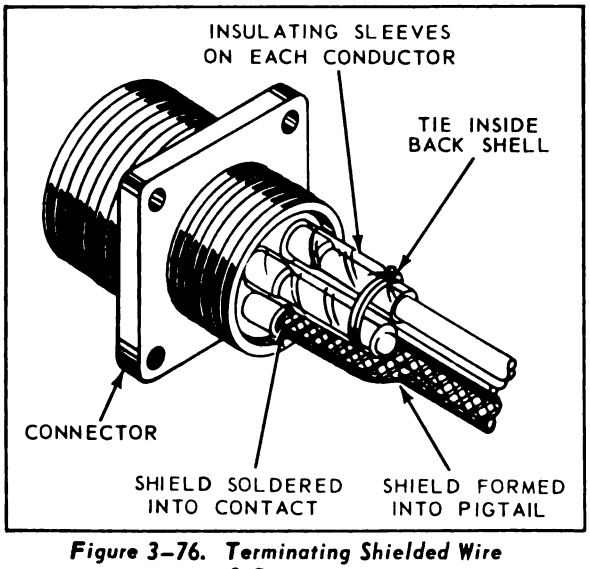


Figure 3-76. Terminating Shielded Wire at MS Connector

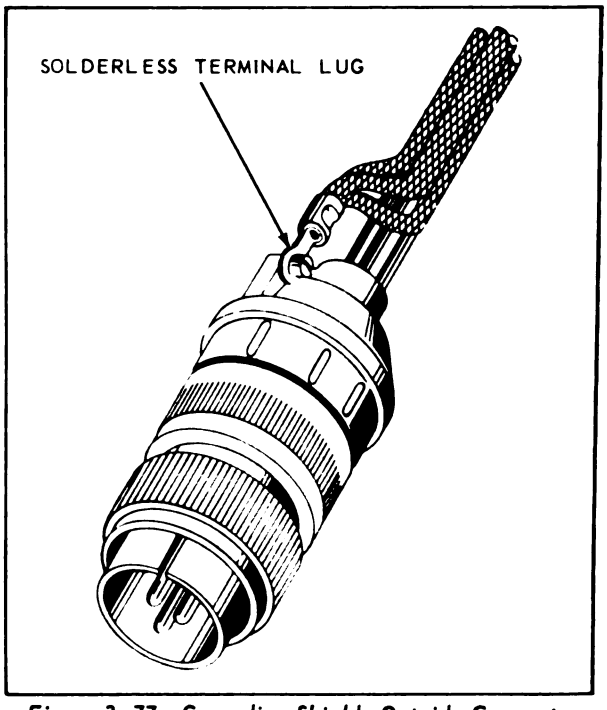


Figure 3-77. Grounding Shields Outside Connector

g. Complete connector assembly in normal manner.

An alternate method for grounding utilizes a screw on the cable clamp to ground the shields as follows:

a. Follow steps a and b, above.

b. Crimp pigtails together into solderless terminal lug.

c. Attach terminal lug under screw, as shown in figure 3-77.

Note

If all shields will not fit into one solderless terminal lug, use several terminal lugs and distribute them under both screws.

3-99. GROUNDING SHIELDS WITH BONDING RING. When specified on the applicable engineering drawing, an AN3111 bonding ring may be used to ground eight or more shields at an AN type connector.

a. Remove washers from the connector cable clamp, and slide clamp back on wire bundle.

b. Install the AN3111 bonding ring on the wire bundle between the connector back shell and the cable clamp, with the bonding ring lug toward the solder contacts.

c. Make a hole in one shield and expand it to hold up to three other shields as shown in figure 3-79. Tighten the expanded shield around the others and sweat solder together. Repeat as necessary for number of shields to be grounded.

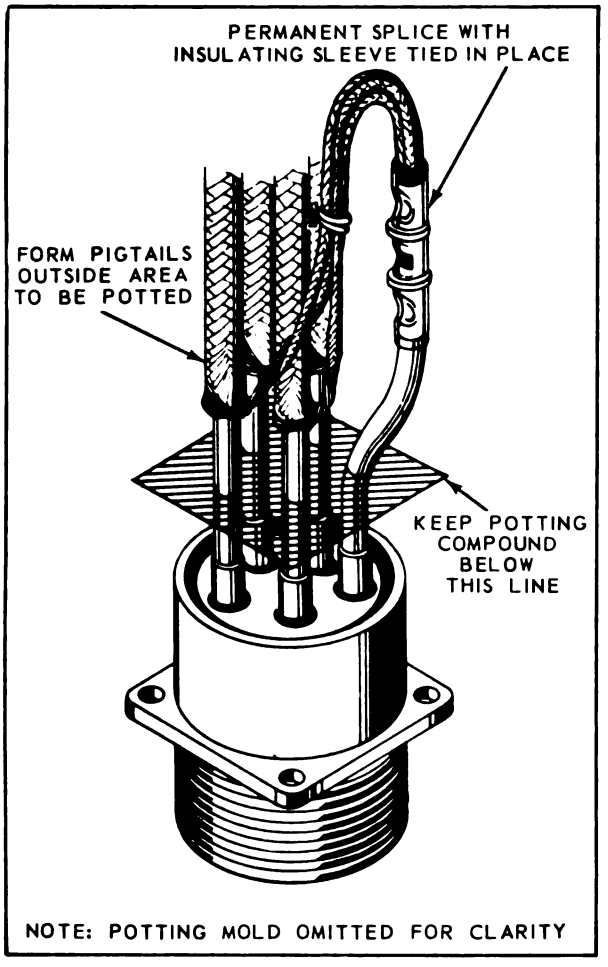


Figure 3–78. Terminating Shielded Wires at Potted Connector

d. Pull one of the shields through to form a jumper. Install a length of insulating sleeving over the jumper shield.

e. Clamp the ears of the bonding ring lug around the jumper(s), and solder. Pull the insulating sleeve over the soldered connection.

3–100. CONNECTING TWO WIRES TO ONE CONTACT. Connect two wires to one contact by using one of the following methods:

a. If both wires can be fitted into contact solder cup, proceed as with single wire. Slide insulating sleeve over both wires together and insert them into solder cup. Make sure all strands are inside cup before soldering. When solder has cooled push insulating sleeve down until it butts against insert. See figure 3–80.

CAUTION

Avoid connecting two wires to one contact in Class E and R connectors; this will cause loss of moisture proofing.

b. If both wires cannot fit into contact solder cup, use permanent splice to join both wires to a third wire which can fit into solder or crimp cup. See section V, paragraph 5–67 for splicing procedure and figure 3–81 for illustration of this connection.

CAUTION

The use of a single wire to terminate two wires at a connector must be approved by engineering.

3–101. REDUCING WIRE SIZE AT MS CONNECTOR. Reduction of wire size to enable a larger diameter wire to be soldered to a smaller diameter contact solder cup is sometimes required. A safe method of making the reduction is as follows:

a. Select a permanent splice which will accommodate the larger wire. Crimp this splice to the stripped wire as described in section V, paragraph 5–63.

b. Select a six inch length of wire which will fit the cup of the contact. Strip one end sufficiently long to be able to double the stripped portion back on itself as shown in figure 3–82.

c. Crimp this doubled wire into the free end of the permanent splice.

CAUTION

Reduction of wire size needs engineering approval. Current carrying capacity of smaller wire or contact must not be exceeded.

3–102. A second method for reducing wire size at an MS connector is by the use of an adapter as shown in figure 3–82. Select an adapter to suit the reduction requirements from table 3–22. The procedure is as follows:

a. Strip wire to a length that the adapter wire well will accommodate.

b. Crimp the wire into the adapter, using the tool listed in table 3–22 for that adapter.

c. Solder the adapter stem to the contact, following the soldering procedure described in 3–42 through 3–47.

3–103. PROTECTION OF ELECTRICAL CONNECTORS. See figure 3–83. Protect all unmated MS connectors with protective covers. Military Standard protective covers and application to connectors is as follows:

MS3180 - For miniature MS plugs with bayonet coupling
MS3181 - For miniature MS receptacles with bayonet coupling
MS3182 - For miniature MS plugs with push-pull coupling
MS3183 - For miniature MS receptacles with push-pull coupling
MS25042 - For standard MS plugs (external thread coupling)
MS25043 - For standard MS receptacles (internal thread coupling)

TABLE 3–22

Installation Tools for Wire-to-Contact Adapters

Part Number	Wire Size	Adapts To	Contact Size	Crimping Tool
1. Thomas & Betts:				
75-14586 - 1	#8 or #10		12	WT 130
C 503	#10 or #12		16	WT 130
75-14586 - 2	#12 or #14		16	WT 130
675-50588	#16 or #18		20	WT 111M
2. Bendix:				
10-74696 - 6	#22		16	
- 4	#16		12	
- 14	#18		12	
- 15	#20		12	
- 1	#10		8	
- 5	#12		8	
-12	#14		8	
- 13	#16		8	
3. Burndy:				
YE 8C12	#8 or #10		12	M8ND, N8CT-4 Die
YE 1216	#12 or #14		16	Y14 MRP
YE 1620	#16 or #18		20	Y16 TMR
YE 1220	#12 or #14		20	Y14 MRP

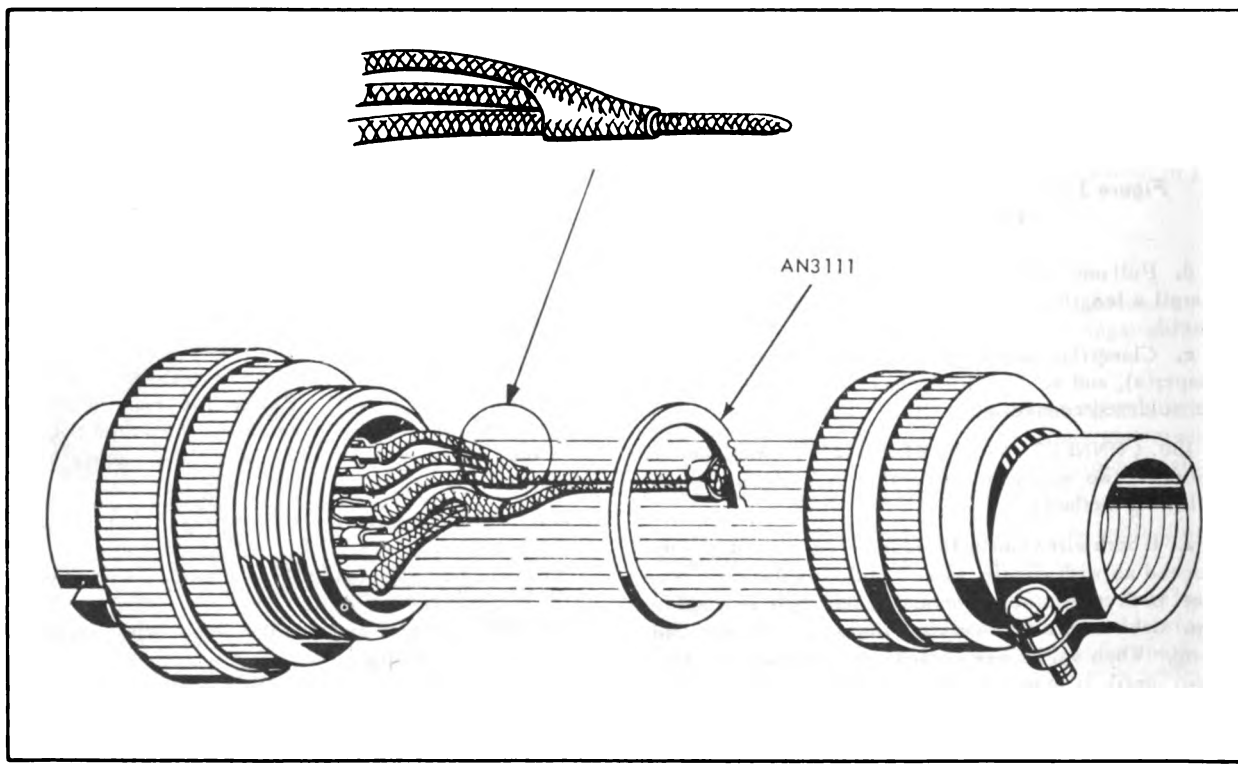


Figure 3–79. Installing AN3111 Bonding Ring

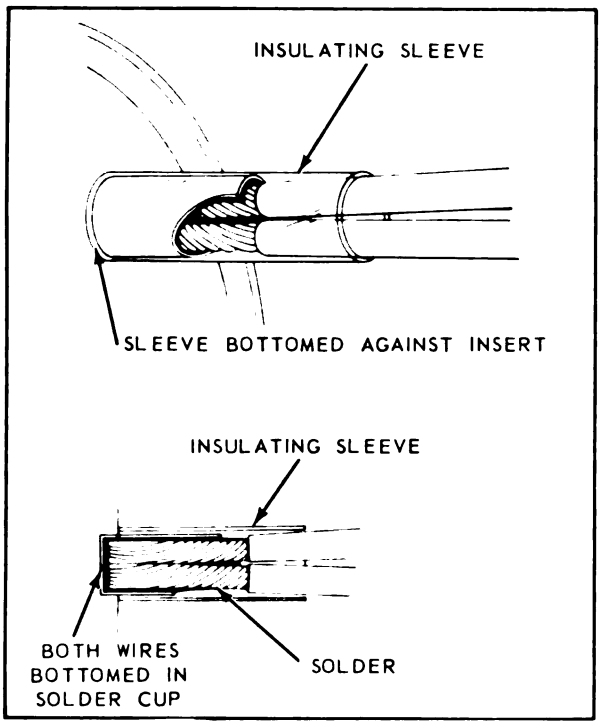


Figure 3–80. Terminating Two Wires at One Contact

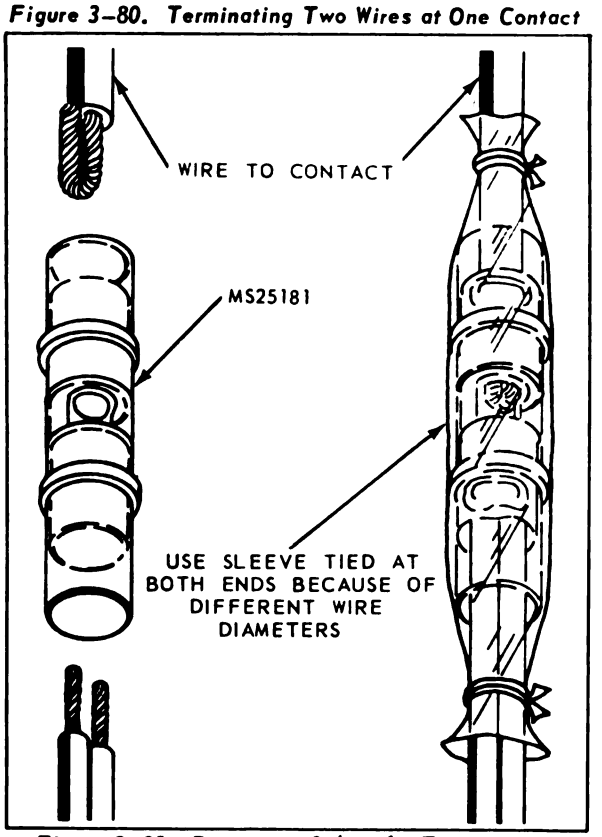


Figure 3–81. Permanent Splice for Terminating Two Wires at One Contact

Use a protective cover with MS dash number corresponding to the shell size of the connector to be protected. Protective covers are available with or without an attaching chain. Plastic dust caps to fit MS plugs (MS25177) and (MS25178) receptacles are also available.

3–104. CONTINUITY TEST. Test all wires and wire groups as fabricated, with terminations attached, for continuity between the termination points specified on the applicable schematic. During the continuity test procedure observe the following precautions:

a. Do not use lead pencils to count pins in connectors; points can break off and lodge in the connector, leading to arcing, shorting, and system malfunction.

b. Do not use oversize prods in connector sockets during testing; this may result in splayed or damaged sockets.

c. Do not puncture wire insulation with a probe, or attach clamps to wire insulation while continuity testing or trouble shooting.

3–105. CONTINUITY TEST PROCEDURE. Use the ohmmeter section of an approved multimeter, such as the TS 352B/U shown in figure 3–84 to determine circuit continuity. Continuity for short runs, where conductor resistance is not a factor, is defined as "zero" resistance. The procedure for determining continuity, using the TS 352B/U, or similar, multimeter is as follows:

a. Set the function control to OHMS, and the range control to the 0-1,000 ohms range. Zero the instrument as directed in the operating manual for the instrument used.

b. Apply the test leads to the terminations of the wire run.

c. Note reading on the ohms scale. A reading of .25 ohms, ± .25 ohms is considered verification of circuit continuity.

Note

The test lead extremities contacting the terminations under test must provide adequate constant contact, and must not damage the termination.

3–106. TEST LEADS. For ground points and terminal lugs, use test leads with alligator clips. For connector pins and sockets, use a special lead ending in a sleeve-insulated pin or socket of the same size as that being tested.

CAUTION

Do not insert an oversize test probe into a connector socket, as this will result in a splayed or damaged contact. Do not hang a test lead from a pin contact as this will result in a bent pin.

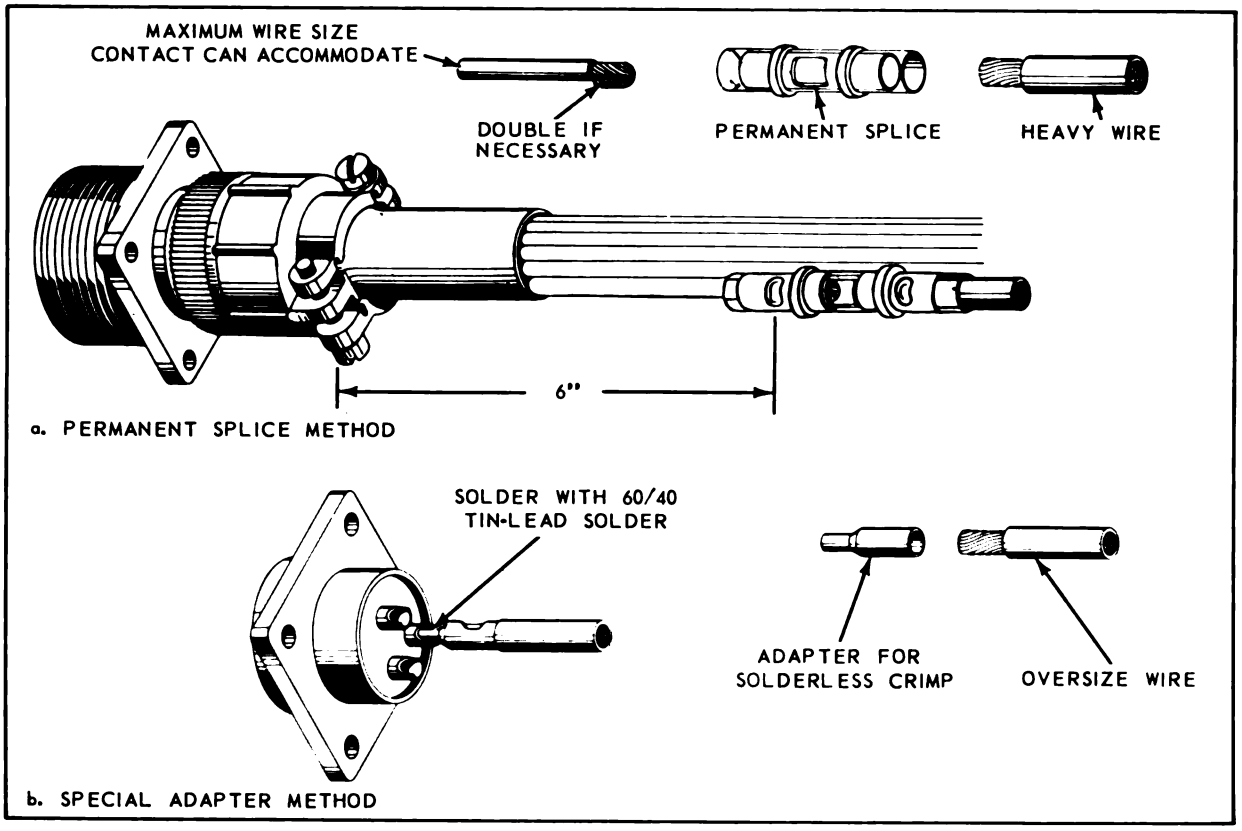


Figure 3–82. Reducing Wire Size at MS Connector

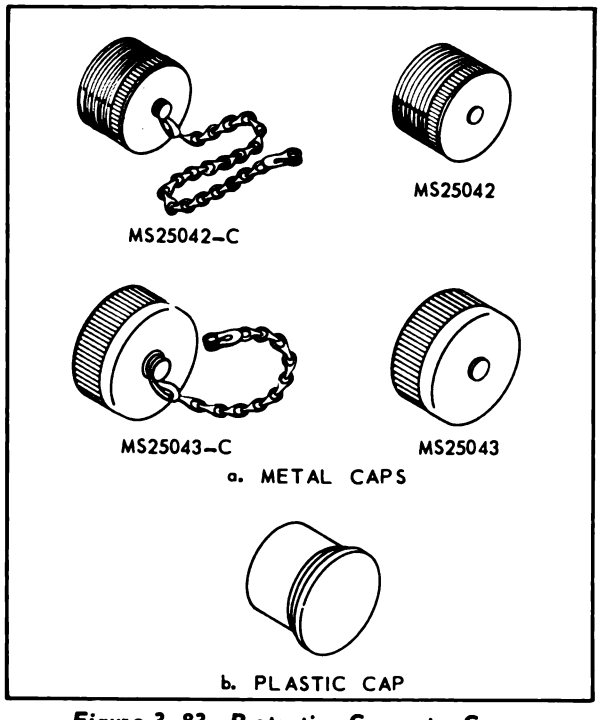


Figure 3–83. Protective Connector Caps

Figure 3–84. Multimeter for Continuity Test (TS 352 B/U)

SECTION IV

RF CONNECTORS AND CABLING

4-1. INTRODUCTION.

4-2. GENERAL. Coaxial cable assemblies are used to carry RF (radio frequency) power from one point to another with a known rate of loss. An assembly consists of RF connectors attached to coaxial cable. The coaxial cable described in this section is of the flexible, solid dielectric type, relatively small to medium size. The characteristic impedance of most of the cable is 50 ohms, but several of the cables listed have a characteristic impedance of 48, 53, 75 or 93 ohms.

4-3. SCOPE. This section describes and illustrates the Military Standard RF connectors and coaxial cable most commonly used in military aircraft and the recommended methods for assembling coaxial cable to the connectors. This section also describes and gives instructions for assembling miniature RF connectors to coaxial cable, and for RF connectors used in fuel quantity indicating systems. General procedures for installation of coaxial cable assemblies into aircraft are given in section XIV.

4-4. REFERENCE SPECIFICATIONS AND DOCUMENTS.

QQ-S-571	Solder, Lead Alloy, Tin-Lead Alloy and Tin Alloy
MIL-C-17	Cables, Radiofrequency, Coaxial
MIL-C-71	Connectors, N, for Radiofrequency Cables
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Non-Rigid
MIL-T-713	Twine and Tape, Lacing and Tying, for use in Electrical and Electronic Equipment
MIL-C-3607	Connectors, Coaxial, RF, Pulse Series
MIL-C-3608	Connectors, Coaxial, RF, Series BNC
MIL-C-3643	Connectors, Coaxial, RF, Series HN
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-A-6091	Alcohol, Ethyl, Specially Denatured
MIL-S-6872	Soldering Process, General Specification for
MIL-I-8660	Insulating and Sealing Compound, Electrical
MIL-C-23329	Connectors, Coaxial, RF, Series BNC, TNC, N and C
MIL-C-25516	Connectors, Electrical, Miniature, Shielded or Unshielded, Environment Resisting Type
MIL-HDBK-216	RF Transmission Lines and Fittings

4-5. DESCRIPTION

4-6. RF CONNECTORS. RF connectors are available as plugs, jacks and panel jacks, and receptacles. Plugs and jacks are attached to the ends of coaxial cables; panel jacks and receptacles are mounted to panels or chassis. Some panel jacks are fastened by means of four screws through holes in a plate integral with the jack body (see figure 4-1). Other panel jacks are fastened by means of a single nut threaded over the jack body (see figure 4-4). Panel jacks and receptacles may be either front or rear-mounted. Plugs always have male contacts; jacks and panel jacks always have female contacts. This section covers the following series of RF connectors:

a. BNC Series. See figure 4-1. A small, lightweight, bayonet type, quick-connect/-disconnect connector, used with small coaxial cables, where peak voltage is not more than 500 volts.

b. HN Series. See figure 4-2. A high voltage (up to 5,000 volts), threaded coupling connector used with medium size coaxial cables.

c. N series. See figure 4-3. A general purpose, threaded coupling connector used with medium size coaxial cables.

d. C Series. See figure 4-4. A late model, bayonet type, quick-connect/-disconnect connector used with medium size coaxial cables. It is electrically similar to the N series.

e. Pulse Series. See figure 4-5. A high-voltage connector for pluse or dc applications. Designed for use with rubber-dielectric pulse cables, but may be used with equivalent-size cables of other contruction where high voltage is not required. With ceramic inserts peak voltage is 15000 v. at sea level. With rubber inserts peak voltage is 5000 v. at 50,000 feet, but higher voltages may be used at lower altitudes.

f. TNC Series. See figure 4-6. A small lightweight connector similar to the BNC series, but having a threaded coupling, used where a positive coupling under vibration and a low noise level is desirable.

g. SC Series. A connector used with medium size coaxial cables; similar to the C series, but having a threaded coupling.

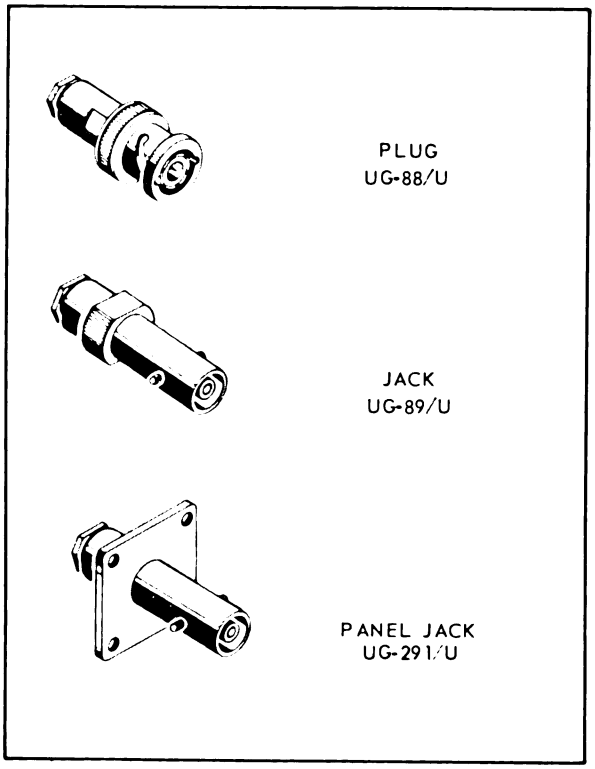


Figure 4–1. Typical BNC Connectors

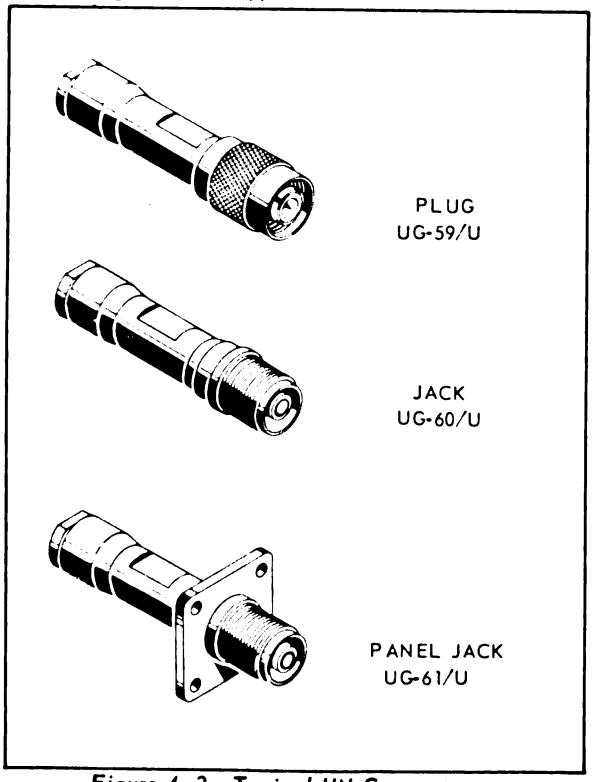


Figure 4–2. Typical HN Connectors

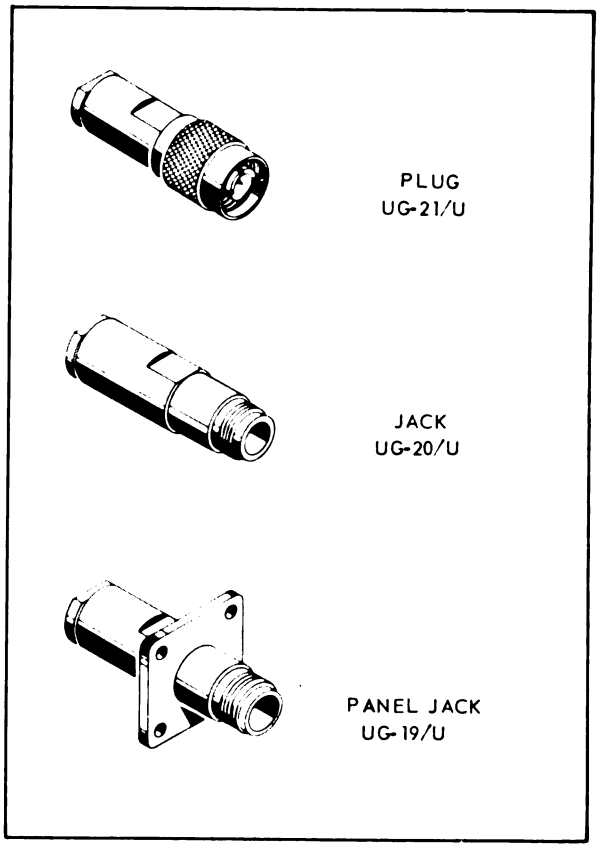


Figure 4–3. Typical N Connectors

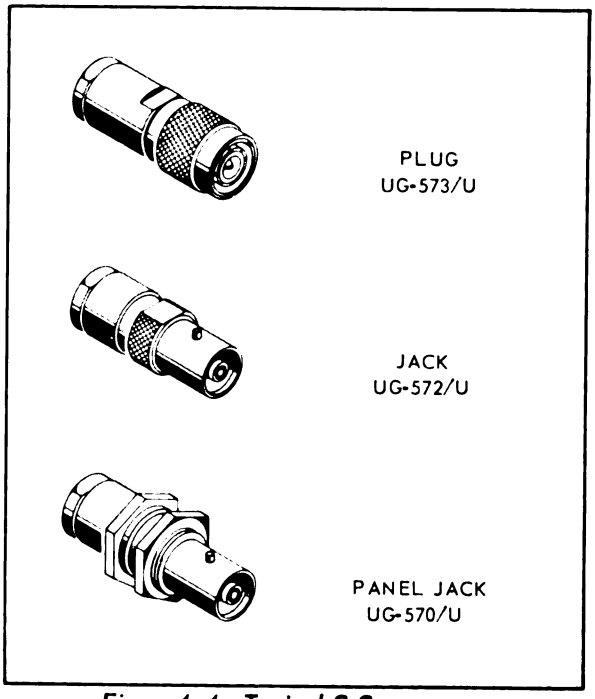


Figure 4–4. Typical C Connectors

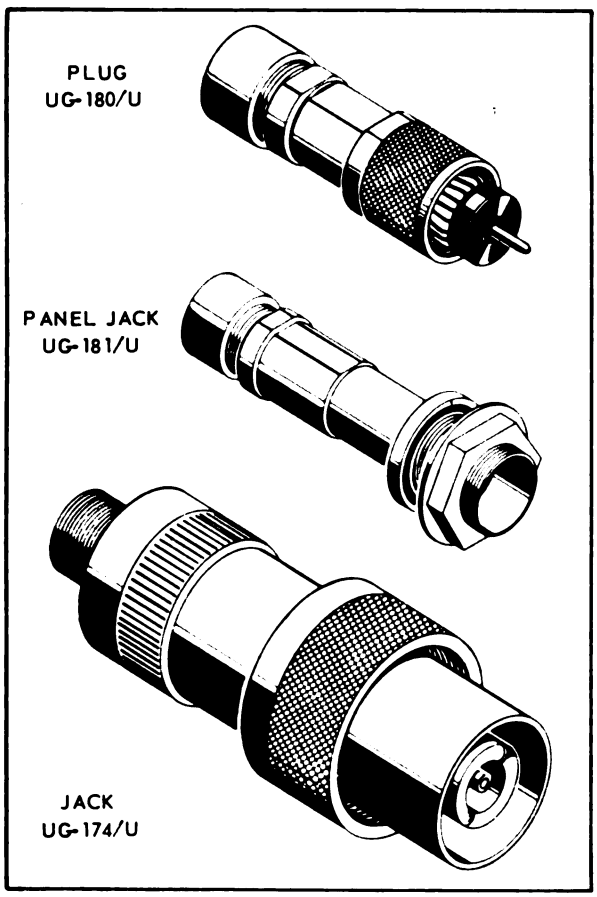


Figure 4–5. Typical Pulse Connectors

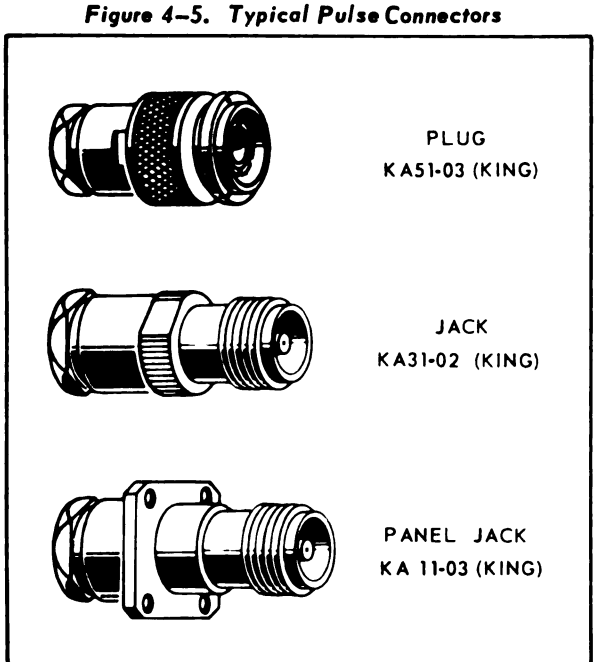


Figure 4–6. Typical TNC Connectors

4–7. COAXIAL CABLE. Coaxial cable consists of an inner (center) conductor separated from the outer conductor, usually called a shield, by an insulating dielectric. The cable is protected against moisture and abrasion by a tough outer jacket (sometimes called a sheath). See figure 4–7 for typical coaxial cables. The inner conductor is usually copper, either solid or stranded, and may be bare, tin plated or silver plated. The outer conductor (shield) is usually a copper braid, bare, tin plated or silver plated, woven over the dielectric. Some coaxial cables have a double outer conductor (double shield) to provide extra shielding. The dielectric has two functions: (1) it provides low loss insulation between the inner conductor and the outer conductor, (2) it maintains the relative position of the inner conductor inside the outer conductor and therefore keeps the capacitance between the two at a constant value.

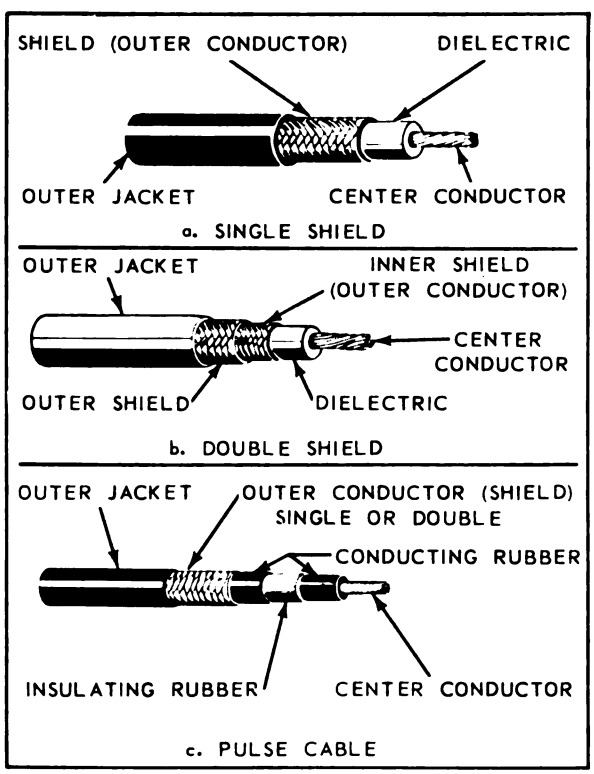


Figure 4–7. Typical Coaxial Cables

4–8. GENERAL PRECAUTIONS AND PROCEDURES.

4–9. GENERAL PRECAUTIONS. A good connection depends on holding coaxial cable and connectors to the design dimensions. Any change in these dimensions will cause added losses to the RF power being carried, and may also cause radiation interference. It is important that the assembly directions given for each connection be followed carefully to avoid trouble. The following precautions are common to all assemblies of the coaxial cable and RF connectors.

4–10. When working with coaxial cable, never step on the cable, set anything heavy on it, or bend it sharply. This will flatten the cable and will change its electrical characteristics. Handle coaxial cable carefully at all times. Anything which damages it, or which might lead to its being damaged later, reduces the efficiency of the system.

4–11. Do not use pliers to assemble or disassemble RF connectors.

4–12. Contacts for RF connectors are usually packed unassembled. Do not misplace them.

4–13. When attaching connectors to coaxial cable having a double shield, make sure both shields are soldered together at connector.

4–14. Use care in starting the nut into a plug or jack body, in order to prevent cross threading.

4–15. Keep soldering iron clean, smooth, and well tinned at all times. See section IX for care of soldering iron.

4–16. GENERAL PROCEDURES. During the preparation of coaxial cable assemblies, observe the following general procedures.

4–17. Cut coaxial cable to length with long handled cable cutters or pruning shears, making sure cut is clean and square.

4–18. Identify cable by using the methods described in section II.

4–19 Strip outer jacket from cable by first making a cut carefully around circumference with a sharp knife. See figure 4–8, step a. Then make a lengthwise slit, step b, and peel off jacket, step c. Take care not to nick, cut or damage shield.

4–20. Comb out the braid by using a pointed wooden dowel or a scriber.

CAUTION

Do not damage dielectric or break shield strands.

4–21. To remove dielectric, cut with sharp knife around circumference, not quite through to center conductor, taking care not to nick or cut strands, or otherwise damage conductor. Pull off dielectric. Another method of stripping the dielectric is to use a soldering iron to which a strip of sheet copper has been fastened as shown in fiture 4–9. The dielectric to be stripped is laid in the "V" and rotated. This will melt a clean break that permits the dielectr ic to be easily removed by hand.

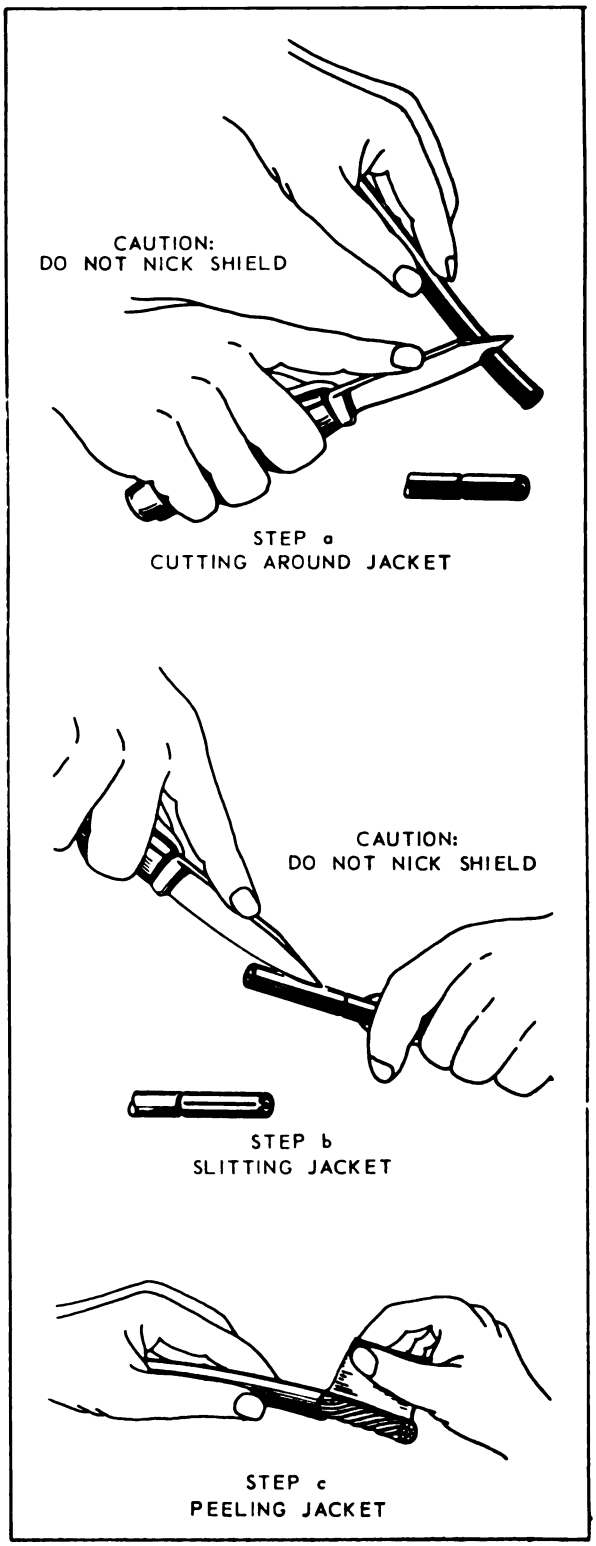


Figure 4–8. Stripping Outer Jacket fron. Coaxial Cable

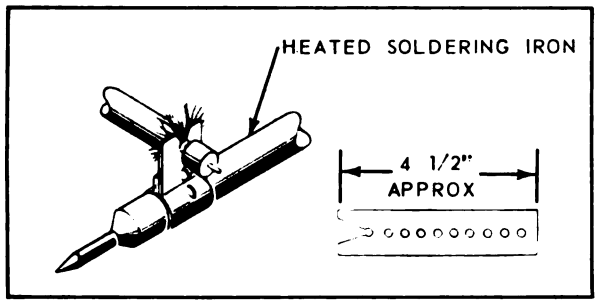


Figure 4–9. Improvised Dielectric Stripper

4–22. Tin center conductor with soldering iron as shown in figure 4–10.

4–23. Tin inside of contacts (male or female) with soldering iron as shown in figure 4–11. (Use untinned face of tip to prevent depositing solder on outside of contact.)

4–24. Solder contacts (male or female) to center conductor with clean, well tinned, soldering iron using 60/40 tin-lead, rosin-core solder. See figure 4–12.

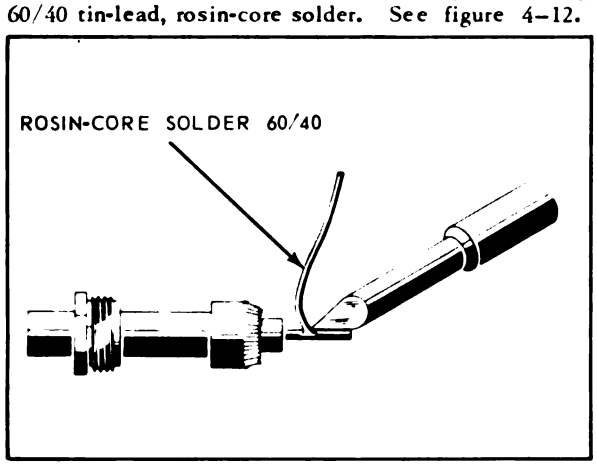


Figure 4–10. Tinning Center Conductor

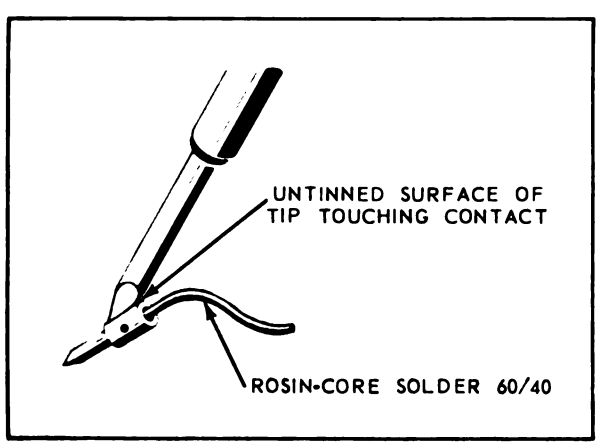


Figure 4–11. Tinning Inside of Contact

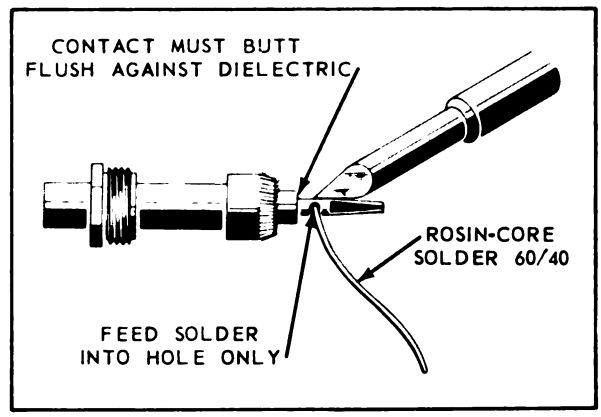


Figure 4–12. Soldering Contact to Coaxial Cable

CAUTION

Contact must butt flush against dielectric before and after soldering.

4–25. When assembling the connector always start the clamping nut into the body by hand, then hold the body assembly in a vise using lead or neoprene jaw protectors. See figure 4–13. Hold body only on the flats. Do not use excessive pressure, since the body can be easily distorted. Tighten nut with end wrench.

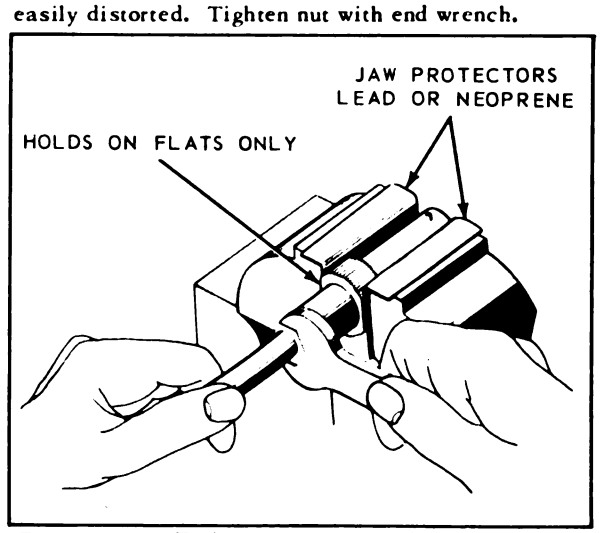


Figure 4–13. Tightening Nut into Plug or Jack Body

4–26. SOLDERING COAXIAL CABLE TO RF CONNECTORS.

4–27. PREPARATION OF WORK. The work to be soldered must be clean and free from oxides. Remove grease by cleaning with Stoddard's solvent, or other approved cleaner. Oxides, if not too heavy are removed by the action of the rosin flux during the soldering operation. Heavily oxidized wire cannot be cleaned by the rosin flux and should be discarded.

4–28. SELECTION OF SOLDERING IRON. For good soldering it is important to select a soldering iron of the proper size and heat capacity. For soldering coaxial cable to RF connectors use an iron with a heating element rated at 65 to 100 watts, and a tip of about 1/4 inch diameter. The soldering tip should be shaped as shown in figure 4–14. Maintain this shape by dressing the tip with a mill smooth file. Make sure the soldering iron is clean, smooth and well-tinned. See section IX for detailed instructions on care and maintenance of the soldering iron.

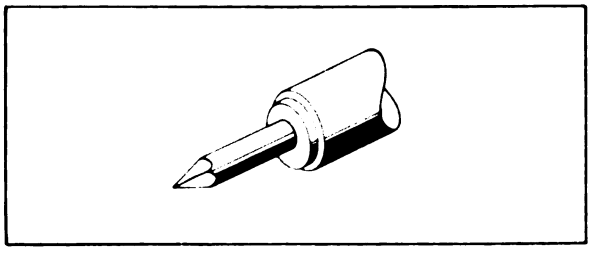


Figure 4–14. Correct Shape for Soldering Iron Tip

Note

For soldering coaxial cable to RF connectors, tin only one face of the tip so that areas adjacent to that being soldered will not be coated with solder by accident.

4–29. SOLDERING PROCEDURE. See section IX for general soldering procedures and precautions. For soldering cable to RF connectors, use only 60–40 tin lead solder with a core of rosin flux. Heat the parts to be joined, and apply the solder at the junction of the soldering iron tip and the work as shown in figure 4–12. Do not apply heat longer than is necessary to melt the solder; excessive heat will swell the dielectric and make it difficult to insert into the body shell. Do not allow solder to flow over the outside of the contact. After the joint has cooled, remove excess flux by wiping with a clean cloth, using denatured alcohol as a solvent if necessary. Remove excess solder from the contact by scraping with a knife. Be careful not to cut into contact or dielectric.

4–30. BNC SERIES CONNECTORS.

4–31. BNC CONNECTOR TYPES. There are two versions of BNC connectors, differing in the method of attaching coaxial cable to the connector body. See figure 4–1 for typical examples of BNC connectors. Table 4–1 lists the more common connectors in the BNC series and shows the coaxial cables associated with each.

a. Improved Version (see figure 4–15) - consists of a plug or jack body assembled to coaxial cable with nut, grooved gasket and sleeve clamp. An insulation bushing is added when assembly is to RG-62/U or 71/U cables. Plug UG-88E/U and Jack UG-89C/U are typical of this version. The sleeve clamp has a sharp rear face which cuts into the grooved gasket and thus makes a tight seal.

b. Captivated Contact Version (see figure 4–16) - similar to the improved version, but with the addition of a bushing and front and rear insulators. When assembly is to RG-62 and 71/U cables a bushing insulator is added between the bushing and rear insulator. This version does not have military numbers.

Note

Bushing and rear insulator used with RG-55/58, 141 and 142/U coaxial cables differ from those used with RG-59, 62, 71 and 140/U cables.

TABLE 4–1

BNC Series Connectors With Associated Cables

Plug	Jack	Panel Jack	For Use With Cable Types
Improved Version:			
UG-88E/U	UG-89C/U	UG-291C/U	RG-55/U, 58/U and 223/U
UG-260D/U	UG-261C/U	UG-262C/U	RG-59/U, 62/U and 71/U
Captivated Contact Version (Amphenol):			
31–301	31–302	31–300	RG-55/U, 58/U, 141/U and 142/U
31–304	31–305	31–303	RG-59/U, 62/U, 71/U and 140/U

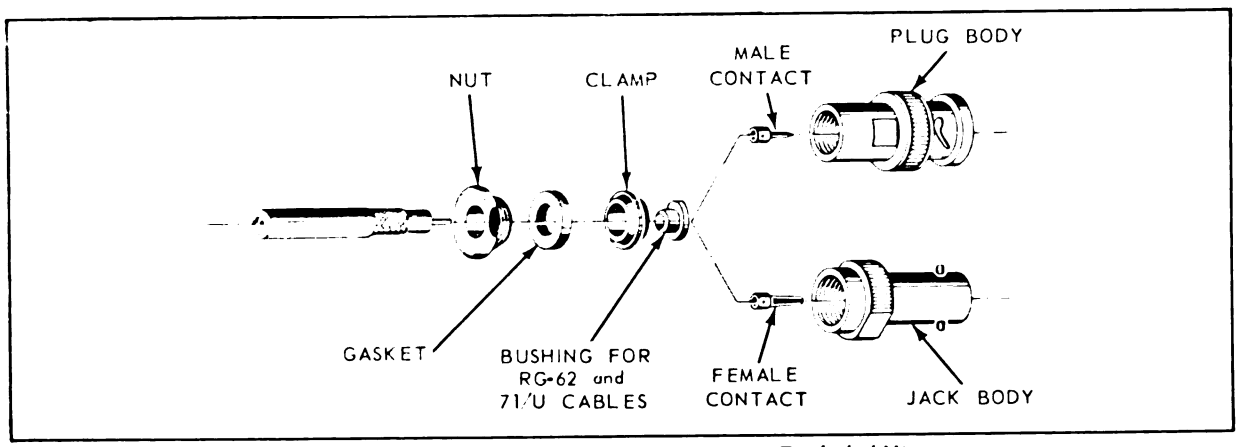


Figure 4–15. Improved BNC Connectors – Exploded View

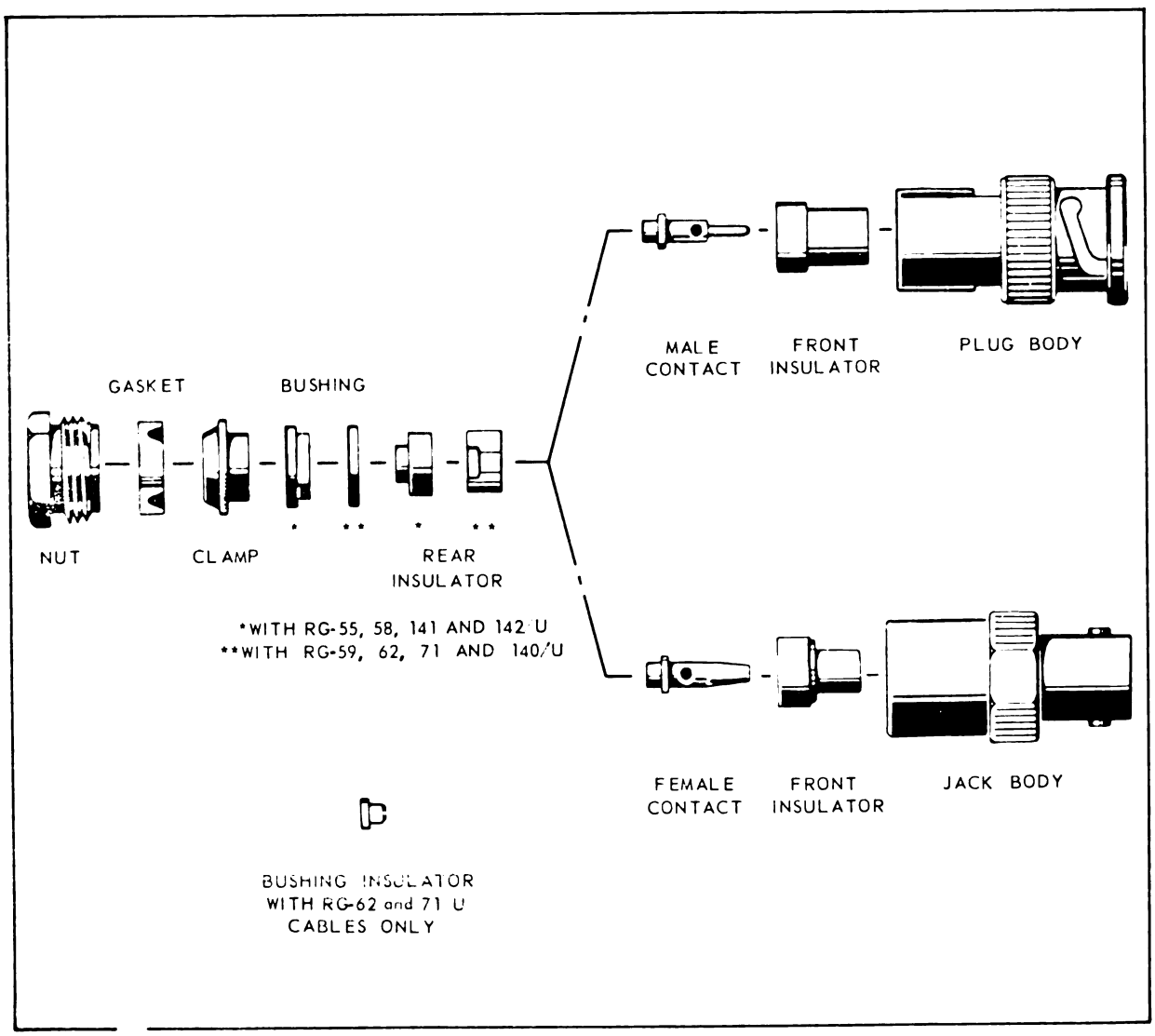


Figure 4–16. BNC Connectors with Captivated Contacts – Exploded View

4–32. ATTACHING IMPROVED BNC CONNECTORS TO COAXIAL CABLE. When attaching improved BNC connectors to coaxial cable (see figure 4–17), follow this procedure:

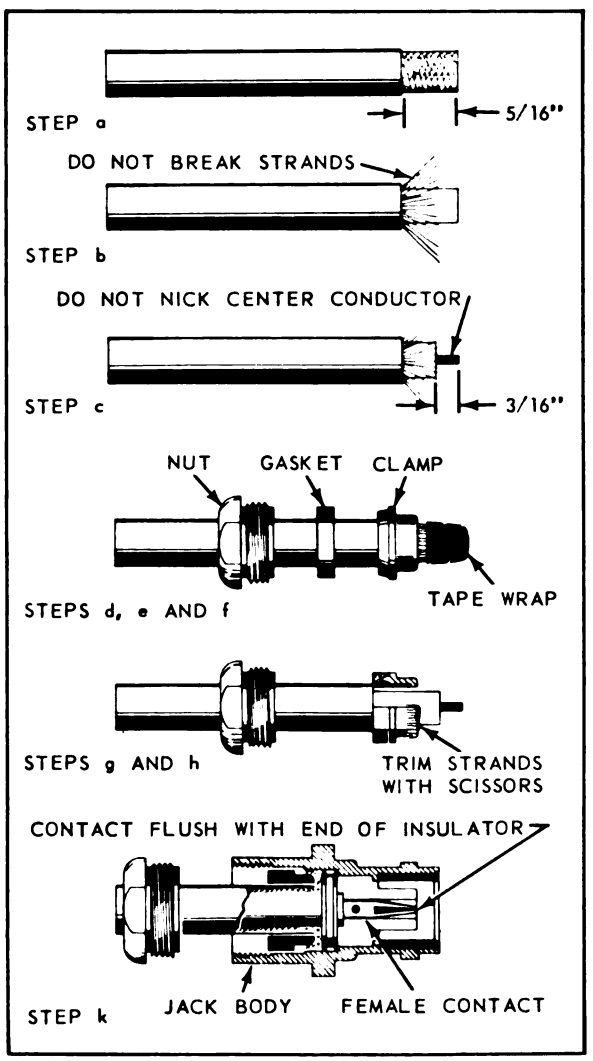


Figure 4–17. Attaching Improved BNC Connectors to Coaxial Cable

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

a. Remove 5/16 inch of outer jacket, exposing shield. See figure 4–8.

CAUTION

Do not nick shield.

b. Comb out shield. Use care to prevent breaking shield strands.

c. Strip dielectric to 3/16 inch from edge of jacket, exposing center conductor.

CAUTION

Do not nick center conductor.

d. Disassemble nut, grooved gasket and sleeve clamp from plug or jack body. See figure 4–15.

e. Taper shield toward center conductor and wrap a piece of thin pressure tape, wide enough to cover the combed out shield (one layer is sufficient) around the shielding, forming a cone with the narrow end toward the conductor.

f. Slide nut and gasket (V-groove away from nut) in that order over tapered shield onto jacket. Slide sleeve clamp over tapered shield until inside shoulder of clamp butts flush against cut end of jacket.

g. Remove tape from shield, comb shield back smoothly over sleeve clamp and trim to 3/32 inch with scissors.

h. Trim dielectric to 1/8 inch from shield, and cut off center conductor to 1/8 inch from edge of dielectric.

i. Tin center conductor as shown in figure 4–10. Tin inside of contact (male or female) as shown in figure 4–11.

j. Slip contact over center conductor so that contact butts flush against dielectric. For RG-62/U and 71/U add bushing. Solder, using a clean, well tinned, soldering iron- contact must still be flush against dielectric after solder has cooled; if it is not remake the joint. See figure 4–12.

CAUTION

Make sure that correct contact is used; a male contact always goes into a plug body, and a female contact always goes into a jack body.

k. Push cable assembly into connector body as far as it will go. Make sure gasket is properly seated, with sharp edge of sleeve clamp entering gasket groove. Slide nut into connector body and fasten in vise. Start nut by hand and tighten with end wrench until enough pressure is applied to make a good seal by splitting the gasket. See figure 4–13.

4–33. ATTACHING BNC CONNECTORS WITH CAPTIVATED CONTACTS TO COAXIAL CABLE. When attaching BNC connectors with captivated contacts to coaxial cable (see figure 4–18), follow this procedure:

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

a. Remove 3/8 inch of outer jacket exposing shield, for all except plugs 31–301 and 31–304; strip jacket for these plugs 27/64 inch. See figure 4–8.

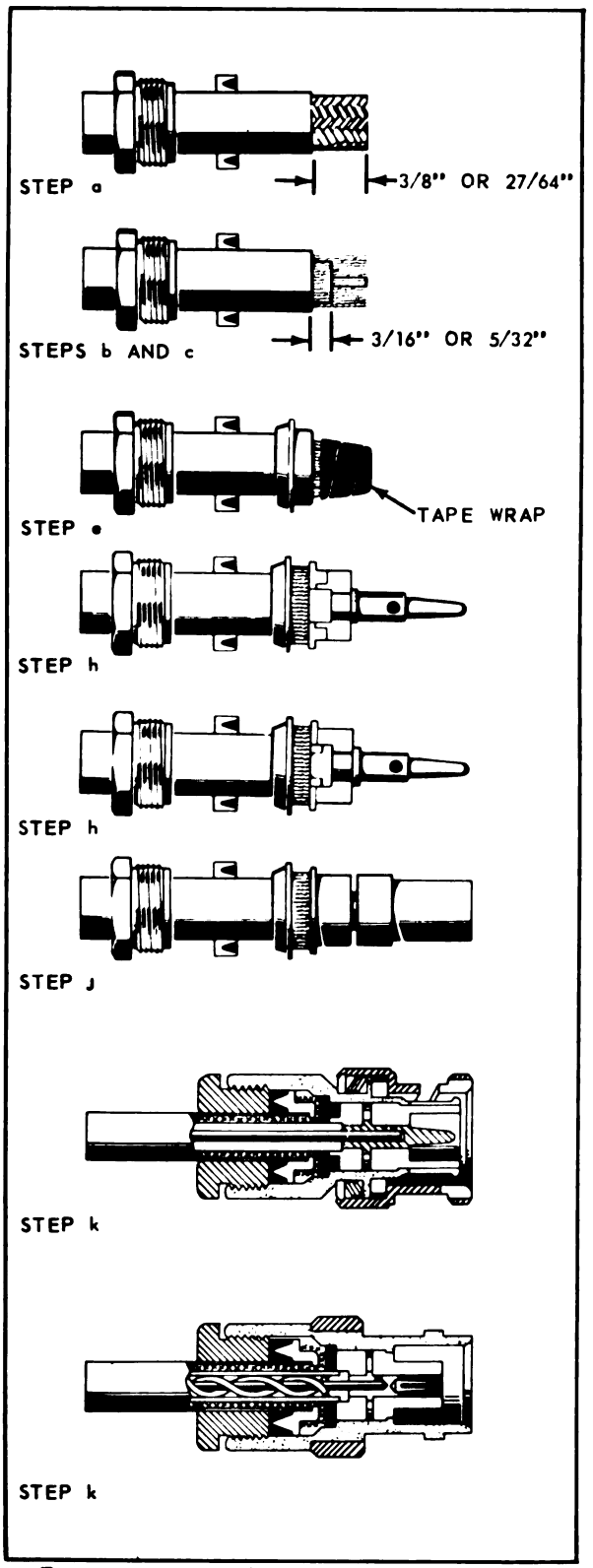


Figure 4–18. Attaching BNC Connectors With Captivated Contacts to Coaxial Cable

CAUTION

Do not nick shield.

b. Comb out shield. Use care to prevent breaking shield strands.

c. Cut off cable dielectric to 3/16 inch for cables RG-55/U, 58/U, 59/U, 140/U, 141/U and 142/U. Cut to 5/32 inch for cables RG-62/U and RG-71/U.

CAUTION

Do not nick center conductor.

d. Disassemble nut, grooved gasket and sleeve clamp from plug or jack body. See figure 4–16.

e. Taper shield toward center conductor, and wrap with tape as described in 4–32. Slide nut and grooved gasket (V-groove away from nut) in that order over tapered shield onto jacket. Slide sleeve clamp over braid and push back against cable jacket.

f. Remove tape, comb shield back smoothly over sleeve clamp and trim to proper length; form evenly over clamp.

g. Tin center conductor as shown in figure 4–10.

h. Slide on bushing, rear insulator and contact. These parts must butt as shown. When attaching to cables RG-62/U and RG-71/U add insulator bushing.

i. Solder contact to center conductor. See figure 4–12. Remove excess flux and solder from outside of contact.

j. Slide front insulator over contact and butt against contact shoulder. Do not reverse direction of insulator.

k. Insert cable assembly into connector body. Make sure that the sharp edge of the clamp seats properly in the gasket. Tighten the nut, holding the body stationary. See figure 4–13.

4–34. C SERIES CONNECTORS.

4–35. C CONNECTORS. (See figure 4-4.) There is only one version of C connector. It consists of a body assembled to coaxial cable by means of a nut, gasket and clamp. Table 4–2 lists the more common connectors in the C series and shows the coaxial cable associated with each. Plug UG-573B/U and Jack UG-572A/U are typical C Connectors. See figure 4–19.

4–36. ATTACHING C CONNECTORS TO COAXIAL CABLE. When attaching C connectors to coaxial cable (see figure 4–20) follow this procedure:

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

a. Disassemble nut, gasket and sleeve clamp from plug or jack body. See figure 4–19.

b. Slide nut and gasket, in that order, onto jacket. Make sure grooved face of gasket is way from nut.

c. Strip outer jacket to "A" dimension given in table 4–3, exposing shield. See figure 4–8.

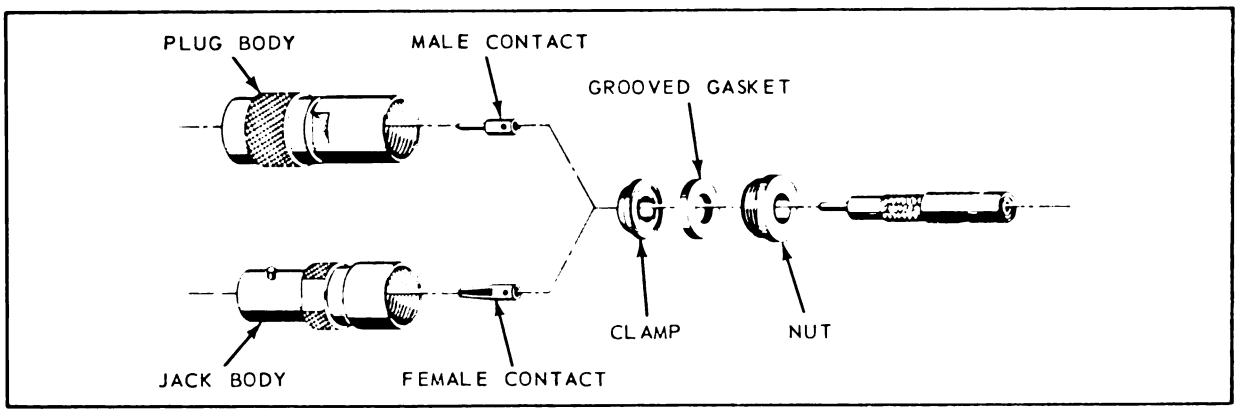


Figure 4–19. C Connectors – Exploded View

TABLE 4–2

C Series Connectors With Associated Cables

Plug	Jack	Panel Jack	For Use With Cable Types
UG–573B/U UG–701B/U	UG–572A/U	UG–570A/U UG–571A/U	RG–8/U, 9/U, 213/U and 214/U
UG–626B/U UG–707A/U	UG–633A/U	UG–629A/U UG–630A/U	RG–5/U, 6/U, and 212/U RG–14/U and 217/U

CAUTION

Do not nick shield.

d. Comb out shield and cut dielectric to "B" dimension given in table 4–3.

CAUTION

Do not nick center conductor.

e. Taper shield toward center conductor and wrap a piece of thin pressure tape, wide enough to cover the combed-out shield (one layer is sufficient) around the shielding, forming a cone with the narrow end toward the conductor.

f. Slide sleeve clamp over tapered shield until inside shoulder of clamp butts against cut end of jacket.

g. Remove tape and fold shield strands back over sleeve clamp taper without overlaps. Trim shield with scissors so that strands end at end of clamp taper.

h. Check that dielectric is exposed exactly to "C" dimension in table 4–3.

i. Tin center conductor as shown in figure 4–10.

j. Tin inside of contact (male or female) as shown in figure 4–11.

k. Slip contact over center conductor so that contact butts flush against dielectric. Solder, using a clean, well tinned soldering iron; contact must still be flush against dielectric after solder has cooled; if it is not, remake the joint. See figure 4–12.

TABLE 4–3

Assembly Dimensions For C Series Connectors

Connectors	Dimensions A	B	C
UG–570/U jack	5/16	5/32	3/64
UG–571/U jack	5/16	5/32	3/64
UG–572/U jack	5/16	5/32	3/64
UG–573/U plug	5/16	5/32	3/64
UG–626/U plug	5/16	5/32	3/64
UG–629/U jack	5/16	5/32	3/64
UG–630/U jack	5/16	5/32	3/64
UG–633/U jack	5/16	5/32	3/64
UG–707/U plug	3/8	13/64	11/64
UG–710/U plug	5/16	5/32	3/64

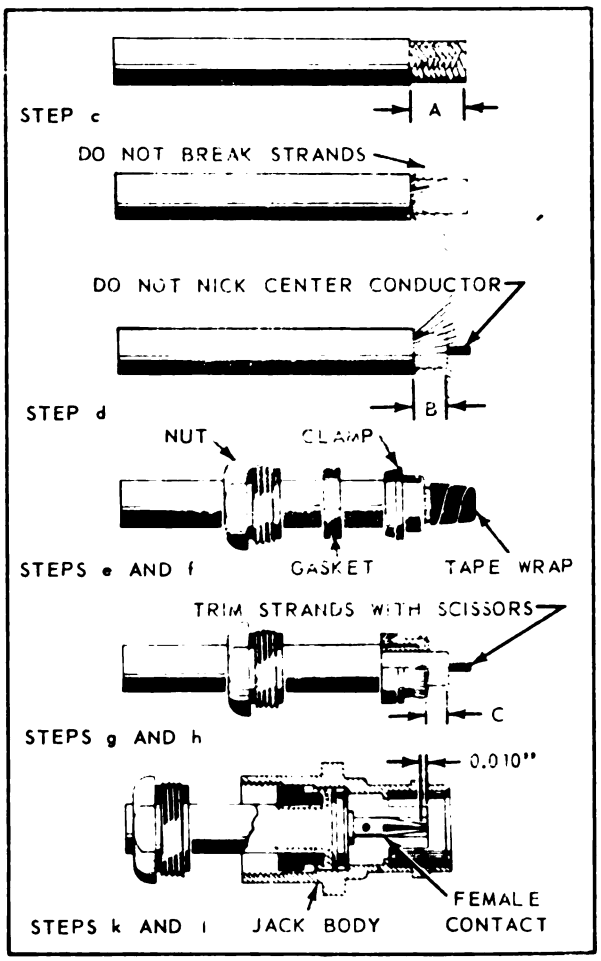


Figure 4–20. Attaching C Connectors to Coaxial Cable

CAUTION

Be sure that correct contact is used; a male contact always goes into a plug body, and a female contact always goes into a jack body.

l. Push cable assembly into connector body as far as it will go. Slide gasket into connector body. Make sure gasket is properly seated, with sharp edge of sleeve clamp entering groove in gasket. Then slide nut into connector body and fasten body in vise. See figure 4–13. Start nut by hand and tighten with end wrench until moderately tight. Gasket should be cut in half during tightening. In plugs, the end of the contact should be flush with insulator. In jacks there should be a clearance of 0.010 inch between end of contact and insulator.

4–37. HN SERIES CONNECTORS.

4–38. HN CONNECTOR TYPES. There are two versions of HN connectors, differing in the method of attaching coaxial cable to the connector body. See figure 4–2 for typical examples of HN connectors. Table 4–4 lists the more common connectors in the HN series and shows the coaxial cables associated with each.

Note

The HN series of RF connectors are used for replacement purposes only.

a. Improved Version (See figure 4–21) - consists of a plug or jack body assembled to coaxial cable with nut, gasket and braid clamp. Plug UG–59E/U and Jack UG-60E/U are typical of this version.

b. Captivated Contact Version (see figure 4–22) - consists of a plug or jack body assembled to coaxial cable with nut, gland, gasket, clamp, sleeve and front and rear insulators. Plug UG-1213/U and jack UG-1214/U are typical of this version.

4–39. ATTACHING IMPROVED HN CONNECTORS TO COAXIAL CABLE. When attaching improved HN connectors to coaxial cable (see figure 4–23), follow this procedure:

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

a. Disassemble nut, grooved gasket and braid clamp from plug or jack body. See figure 4–21.

b. Remove 11/16 inch from outer jacket, exposing shield. See figure 4–8.

TABLE 4–4

HN Series Connectors With Associated Cables

Plug	Jack	Panel Jack	For Use With Cable Types
*UG–59E/U **UG–1213/U	*UG–60E/U **UG–1214/U	*UG–61E/U **UG–1215/U	RG8/U, 9/U, 213/U and 214/U

*Improved Version; **Captivated Contact Version

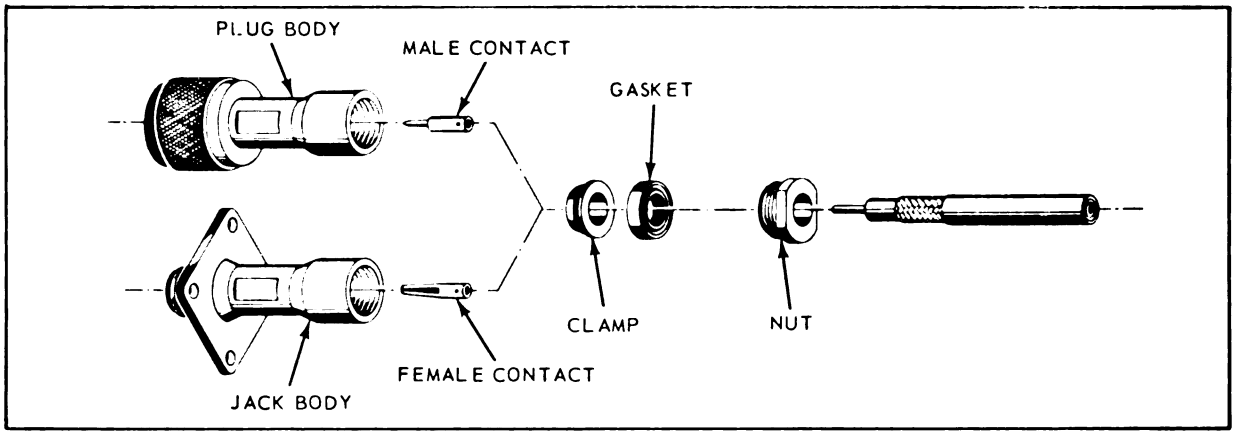


Figure 4–21. Improved HN Connectors – Exploded View

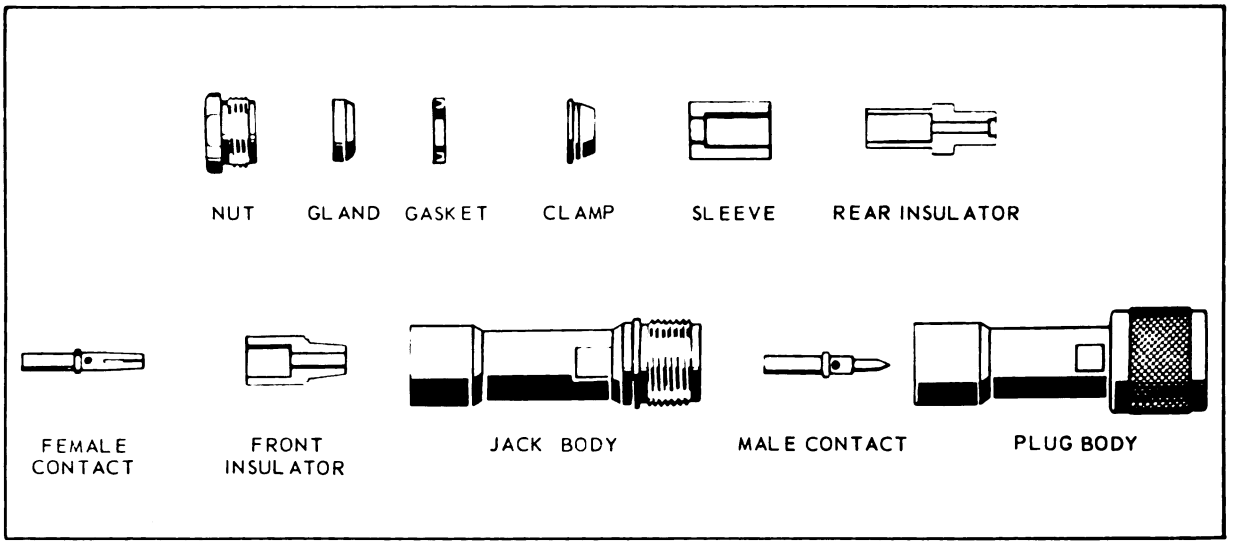


Figure 4–22. HN Connectors with Captivated Contacts – Exploded View

CAUTION

Do not nick shield.

c. Comb out shield and strip dielectric 1/4 inch.

CAUTION

Do not nick center conductor.

d. Taper shield toward center conductor and wrap a piece of thin pressure tape, wide enough to cover the combed-out shield (one layer is sufficient) around the shielding, forming a cone with the narrow end toward the conductor.

e. Slide nut and gasket in that order over tapered shield onto jacket. Make sure that groove in gasket faces away from the nut.

f. Slide clamp over shield until inside shoulder of clamp butts flush against cut end of jacket.

g. Remove tape from shield, and fold shield strands back over clamp without overlaps. Trim strands with scissors, so that all strands end at end of clamp taper.

h. Tin center conductor as shown in figure 4–10.

i. Tin inside of contact (male or female) as shown in figure 4–11.

j. Slip contact over center conductor so that contact butts flush against dielectric. Solder, using a clean, well tinned, soldering iron; contact must still be flush against dielectric after solder has cooled; if it is not, remake the joint. See figure 4–12.

CAUTION

Make sure that correct contact is used; a male contact always goes into a plug body, and a female contact always goes into a jack body.

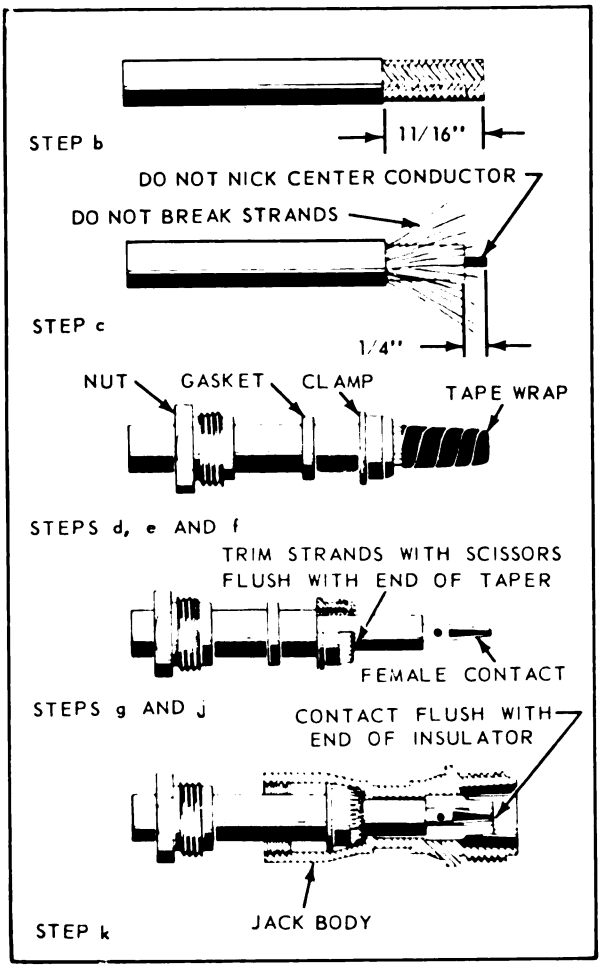


Figure 4–23. Attaching Improved HN Connectors to Coaxial Cable

k. Push cable assembly into connector body as far as it will go. Slide gasket into connector body; make sure gasket is properly seated with sharp edge of braid clamp entering groove in gasket. Slide nut into connector body and fasten body in vise (see figure 4–13.) Start nut by hand and tighten with end wrench until moderately tight.

Note

Gasket should be cut in half during tightening.

4–40. ATTACHING HN CONNECTORS WITH CAPTIVATED CONTACTS TO COAXIAL CABLE. When attaching HN connectors with captivated contacts to coaxial cable (see figure 4–24), follow this procedure:

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

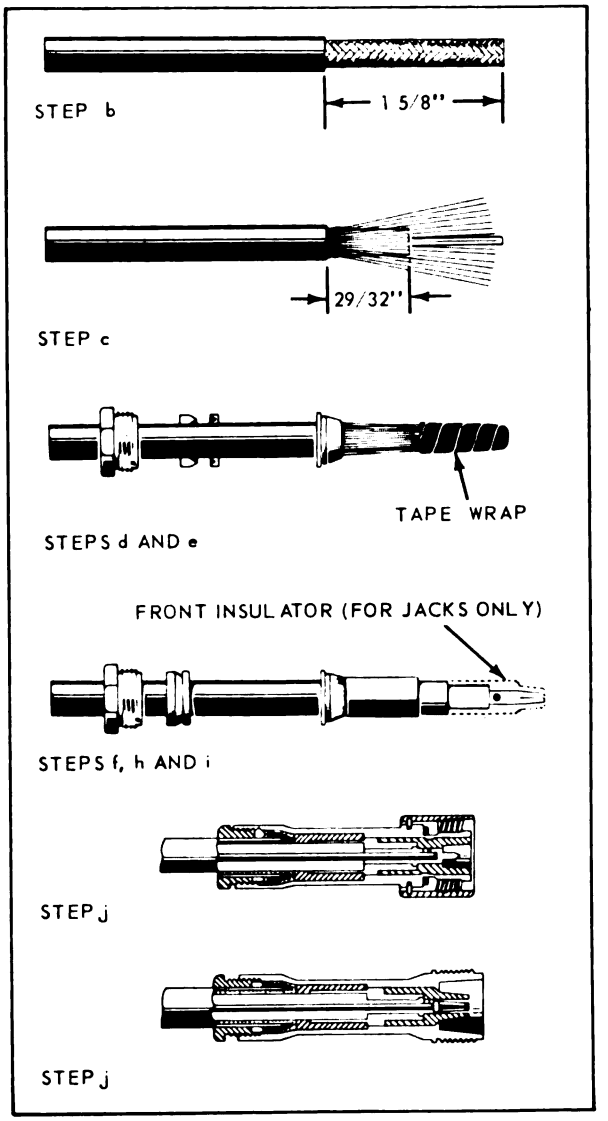


Figure 4–24. Attaching HN Connectors with Captivated Contacts to Coaxial Cable

a. Disassemble nut, gland, gasket, clamp, sleeve and front and rear insulators from plug or jack body. See figure 4–22.

b. Remove 1-5/8 inches from outer jacket, exposing shield. See figure 4–8.

CAUTION

Do not nick shield.

c. Comb out shield and cut off dielectric 29/32 inch from end of jacket.

CAUTION

Do not nick center conductor.

d. Taper braid wires forward and wrap with tape as described in 4-39d. Slide nut and gland onto jacket. Make sure that sharp edge of gland is toward end of cable. Then slide gasket onto jacket with "V" groove toward gland.

e. Slide clamp over the braid until inside shoulder of clamp butts flush against end of jacket.

f. Remove tape, and fold shield strands back over clamp without overlaps. Trim strands with scissors so that all strands end at end of clamp taper.

g. Tin center conductor as shown in figure 4-10, using minimum amount of heat.

h. Slide sleeve and rear insulator over cable dielectric. Slip contact over center conductor. Rear insulator must seat against cable dielectric, and contact shoulder must be flush with insulator face. Solder contact to center conductor. (See figure 4-12).

i. For jacks only, install front insulator.

CAUTION

Make sure that correct contact is used; a male contact always goes into a plug body, and a female contact always goes into a jack body.

j. Push cable assembly carefully into connector body as far as it will go. Make sure that sharp edge of gland remains in the gasket groove. Tighten nut with wrench, holding body stationary. (see figure 4-13).

Note

Gasket should be cut in half during tightening.

4-41. N SERIES CONNECTORS.

4-42. N CONNECTOR TYPES. There are two versions of N connectors, differing in the method of attaching coaxial cable to the connector body. See figure 4-3 for typical examples of N connectors. Table 4-5 lists the more common connectors in the N series and shows the coaxial cables associated with each.

a. Improved Version (See figure 4-25) - consists of a body assembled to coaxial cable with nut, grooved gasket and clamp. Plug UG-18D/U and Jack UG-20D/U are typical of this version. The sleeve clamp has a sharp rear face, which cuts into the grooved gasket when the nut is tightened.

b. Captivated Contact Version (See figure 4-26) - consists of a body assembled to coaxial cable with nut, grooved gasket, clamp, washer and front and rear insulators. The plug body assembly omits the rear insulator. Plug UG-1185/U and Jack UG-1186/U are typical of this version.

4-43. ATTACHING IMPROVED N CONNECTORS TO COAXIAL CABLE. When attaching improved N connectors to coaxial cable (see figure 4-27), follow this procedure:

Note

While attaching connector, observe all general precautions and procedures listed in 4-9 through 4-25.

a. Remove 9/32 inch of outer jacket, exposing shield. See figure 4-8.

CAUTION

Do not nick shield.

b. Comb out shield and strip dielectric to 1/8 inch from end of jacket, exposing 5/32 inch of center conductor.

TABLE 4-5

N Series Connectors With Associated Cables

Plug	Jack	Panel Jack	For Use With Cable Types
Improved Version:			
UG-18D/U	UG-20D/U	UG-19D/U	RG-5/U, 6/U, 21/U and 212/U
UG-21E/U UG-594A/U	UG-23E/U	UG-23E/U UG-160D/U	RG-8/U, 9/U, 213/U and 214/U
UG-536B/U			RG-55/U and 58/U
Captivated Contact Version:			
UG-1185/U	UG-1186/U	UG-1187/U	RG-8/U, 9/U, 213/U and 214/U

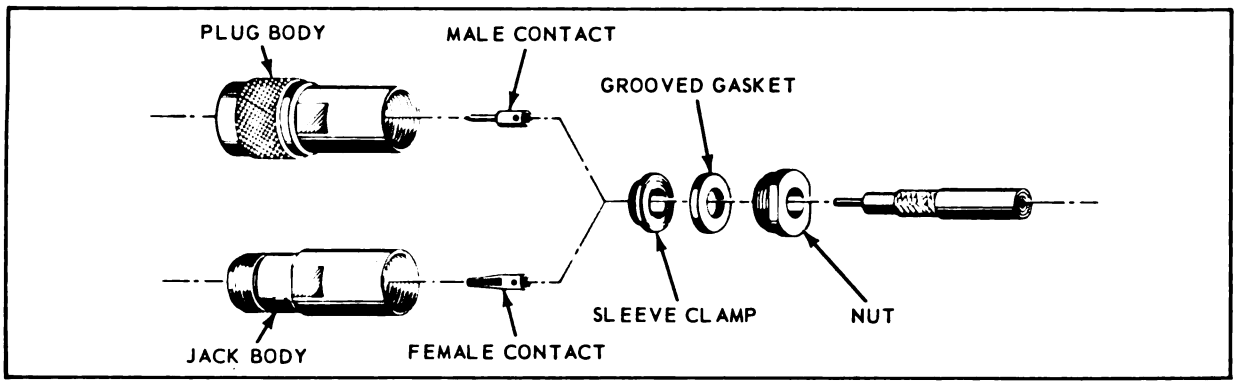


Figure 4–25. Improved N Connectors – Exploded View

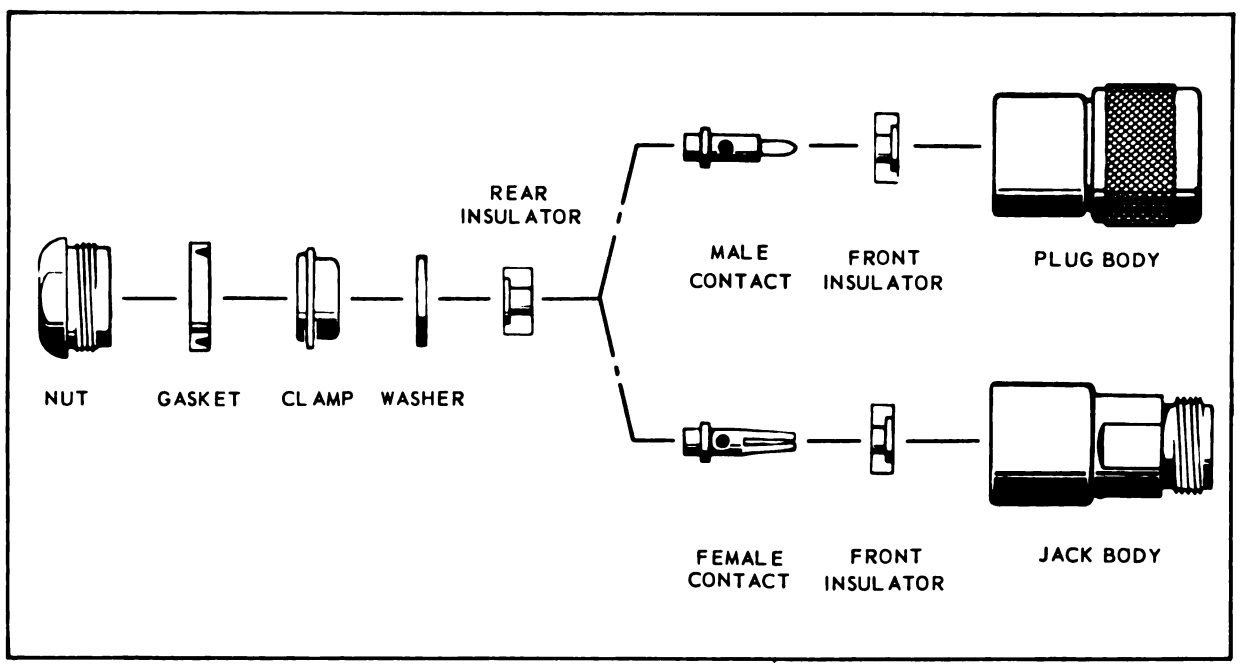


Figure 4–26. N Connectors with Captivated Contacts – Exploded View

CAUTION

Do not nick center conductor.

c. Disassemble nut, gasket and sleeve clamp from plug or jack body. See figure 4–25.

d. Taper shield toward center conductor and wrap a piece of thin pressure tape, wide enough to cover the combed-out shield (one layer is sufficient) around the shielding, forming a cone with the narrow end toward the conductor.

e. Slide nut and gasket in that order over taped shielding onto jacket. Make sure that grooved side of gasket faces away from the nut. Slide clamp over shield until inside shoulder of clamp butts flush against cut end of jacket.

f. Remove tape, and fold shield strands back over sleeve clamp taper without overlaps. Trim shield with scissors, so that strands end at end of clamp taper.

g. Check that exposed dielectric is .045 inch beyond shield.

h. Tin center conductor as shown in figure 4–10.

i. Tin inside of contact (male or female) as shown in figure 4–11.

j. Slip contact over center conductor so that contact butts flush against dielectric. Solder, using a clean, well tinned soldering iron; contact must still be flush against dielectric after solder has cooled; if it is not, remake the joint. See figure 4–12.

CAUTION

Be sure that correct contact is used; a male contact always goes into a plug body, and a female contact always goes into a jack body.

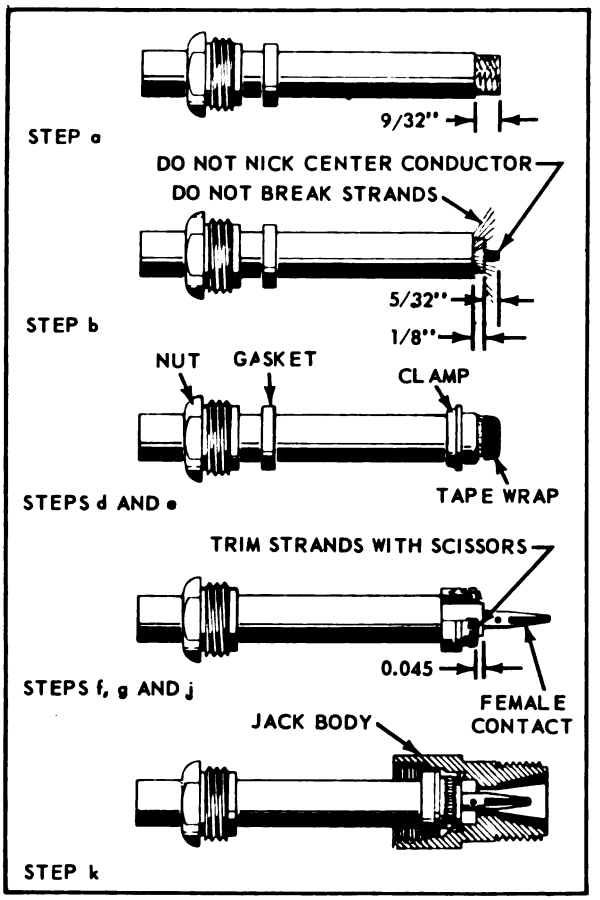


Figure 4–27. Attaching Improved N Connectors to Coaxial Cable.

k. Push cable assembly into connector body as far as it will go. Slide gasket into connector body. Be sure knife edge of sleeve clamp seats into groove of gasket. Then slide nut into connector body and fasten body in vise. See figure 4–13. Start nut by hand, tighten with end wrench until moderately tight. Gasket should be cut in half during tightening.

4–44. ATTACHING N CONNECTORS WITH CAPTIVATED CONTACTS TO COAXIAL CABLE. When attaching captivated-contact N connectors to coaxial cable (see figure 4–28) follow this procedure:

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

a. Remove 23/64 inch of outer jacket, exposing shield. See figure 4–8.

CAUTION

Do not nick shield.

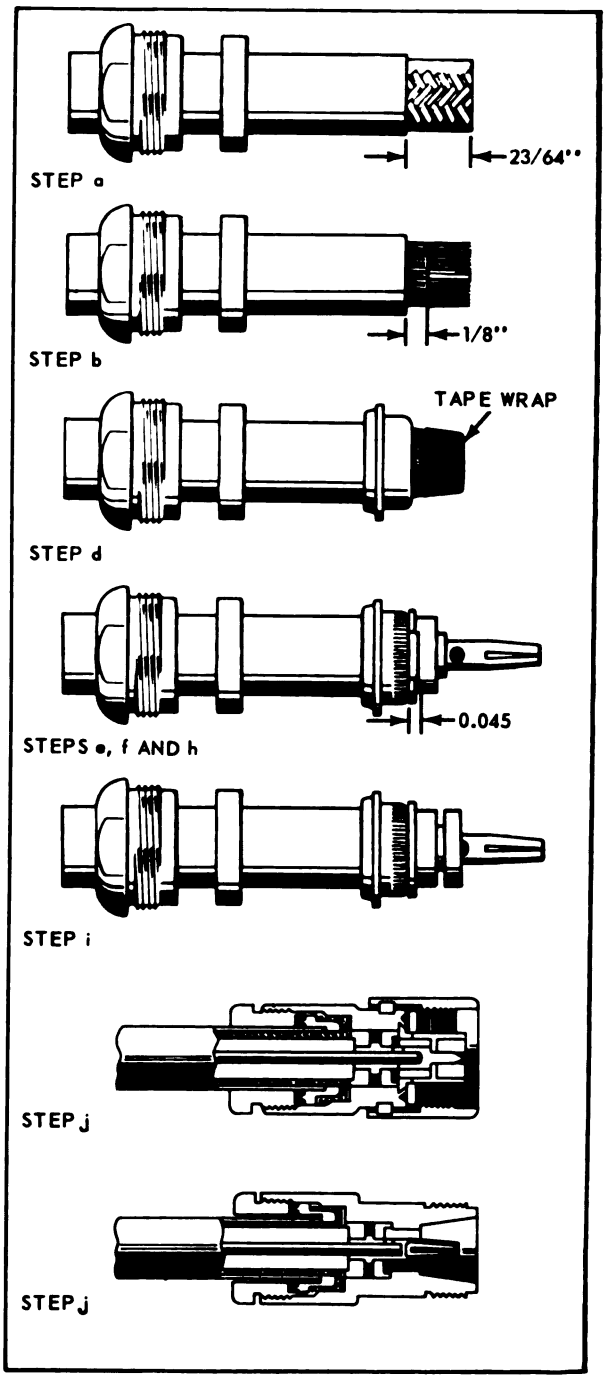


Figure 4–28. Attaching N Connectors with Captivated Contacts to Coaxial Cable

b. Comb out shield, and cut off cable dielectric 1/8 inch from end of jacket.

CAUTION

Do not nick center conductor.

c. Disassemble nut, gasket, clamp, washer and insulator (s) from plug or jack body.

d. Taper shield toward center conductor, and wrap with tape as described in 4–43. Slide nut and gasket in that order, over tapered shield onto jacket. Make sure grooved side of gasket faces away from nut. Then slide clamp over tapered shield and push back against cable jacket.

e. Remove tape, and fold shield strands back over clamp taper without overlaps. Trim shield with scissors so that strands end at end of clamp taper.

f. Check that exposed dielectric is .045 inch beyond shield.

g. Tin center conductor as shown in figure 4–10, using minimum amount of heat.

h. Slide on washer, rear insulator and contact, so that the counterbored end of the rear insulator butts flush against the dielectric, and the contact shoulder butts flush against the rear insulator. Solder the contact to center conductor. (See figure 4–12).

CAUTION

Make sure that the correct contact is used; a male contact always goes into a plug body and a female contact always goes into a jack body.

I. Slide front insulator over contact; make sure the counterbored end of the insulator is toward the mating end of the contact.

j. Push the cable assembly into the connector body. Make sure that the sharp edge of the clamp seats properly in the gasket. Tighten the nut, holding the body stationary, (see figure 4–13).

4–45. PULSE SERIES CONNECTORS.

4–46. PULSE CONNECTOR TYPES. There are two versions of pulse connectors. These versions differ in the material of the inserts, and in the method of attaching the coaxial cable to the connector body. See figure 4–5 for typical examples of pulse connectors. Table 4–6 lists the more common connectors in the pulse series and shows the coaxial cables associated with each.

a. Ceramic Insert Version (See figure 4–29) - consists of a plug or jack body assembled to coaxial cable with nut, cable clamp, washer and corona shield. Plug UG-174/U is typical of this version.

b. Rubber Insert Version (See figure 4–30)- consists of a plug or jack body assembled to coaxial cable with clamp, washer, gasket, sleeve and ferrule. Plug UG-180A/U and Jack UG-182A/U are typical of this version.

4–47. ATTACHING CERAMIC INSERT PULSE CONNECTORS TO COAXIAL CABLE.

Note

The following procedure is for assembling UG-174/U plug to RG-28/U cable, and UG-34/U plug to RG-25/U cable. The two assemblies differ in dimensions as indicated in the procedure steps. Both cables have a double shield.

When attaching ceramic insert pulse connectors to coaxial cable (see figure 4–31) follow this procedure:

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

a. Disassemble nut, cable clamp, washer and corona shield from plug or jack body. See figure 4–29.

b. Slide nut and cable clamp in that order onto cable jacket. Remove 3-5/8 inches of outer jacket of RG-28/U cable and 2-3/4 inches of RG-25/U cable exposing first shield, (see note at beginning of paragraph). See figure 4–8.

CAUTION

Do not nick shield.

c. Remove first shield to 5/16 inch from cut edge of outer jacket exposing insulating tape.

d. Comb out shield and bend at right angles, as shown. Remove insulating tape even with cut edge of outer jacket, exposing second shield.

TABLE 4–6

Pulse Series Connectors with Associated Cables

Plug	Jack	Panel Jack	For Use With Cable Types
Ceramic Insert:			
UG-34/U			RG-25/U
UG-174/U			RG-28/U
Rubber Insert:			
UG-180A/U	UG-182A/U UG-1086/U	UG-181A/U	RG-25/U, 64/U, 77/U, 78/U and 88/U

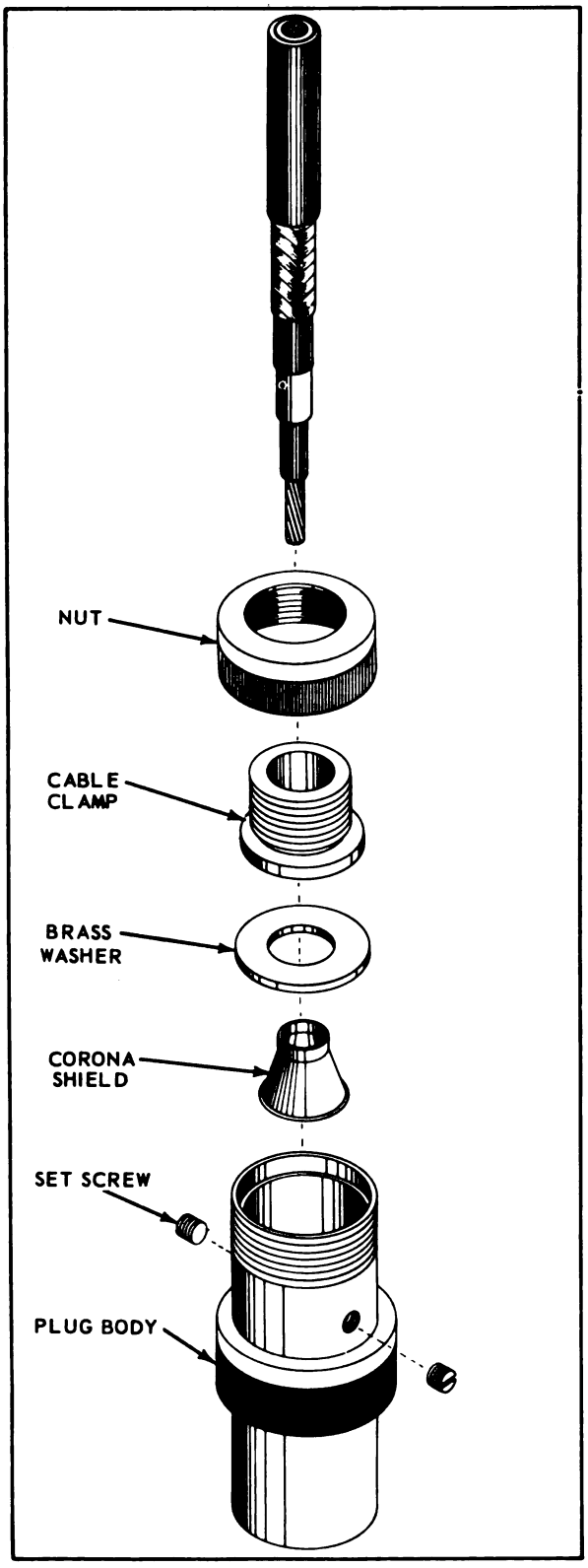


Figure 4–29. Pulse Connector – Ceramic Insert

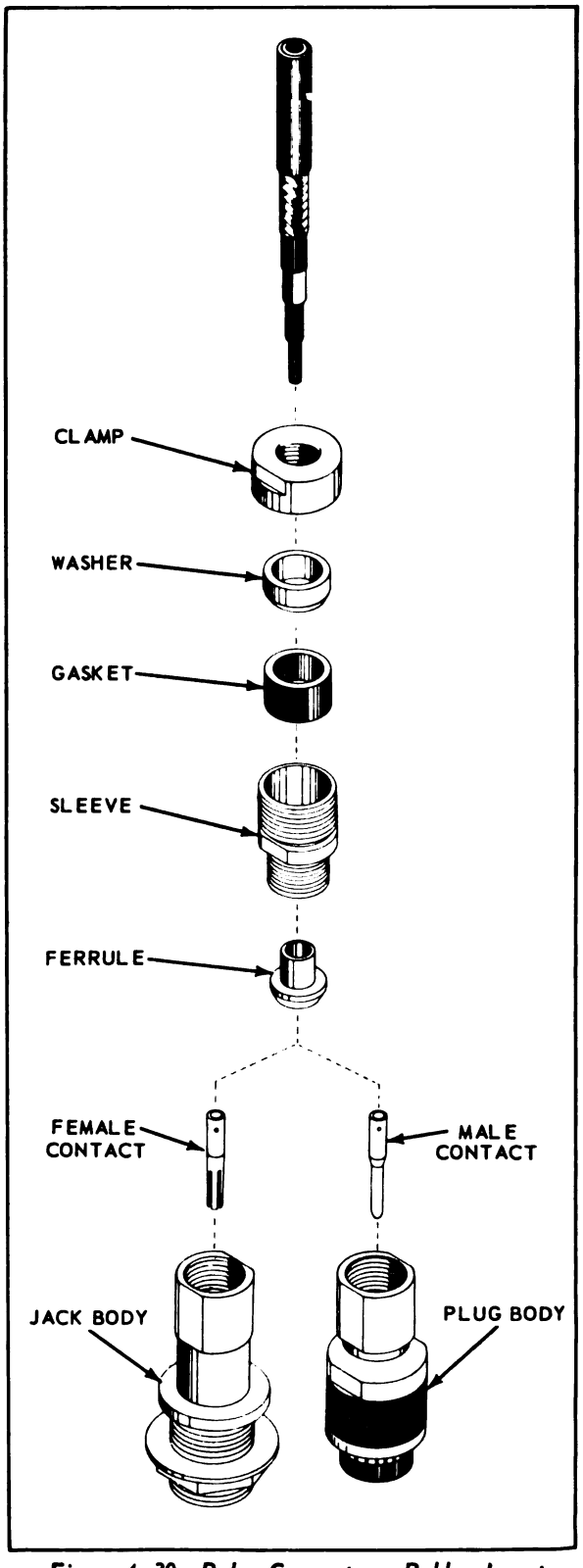


Figure 4–30. Pulse Connector – Rubber Insert

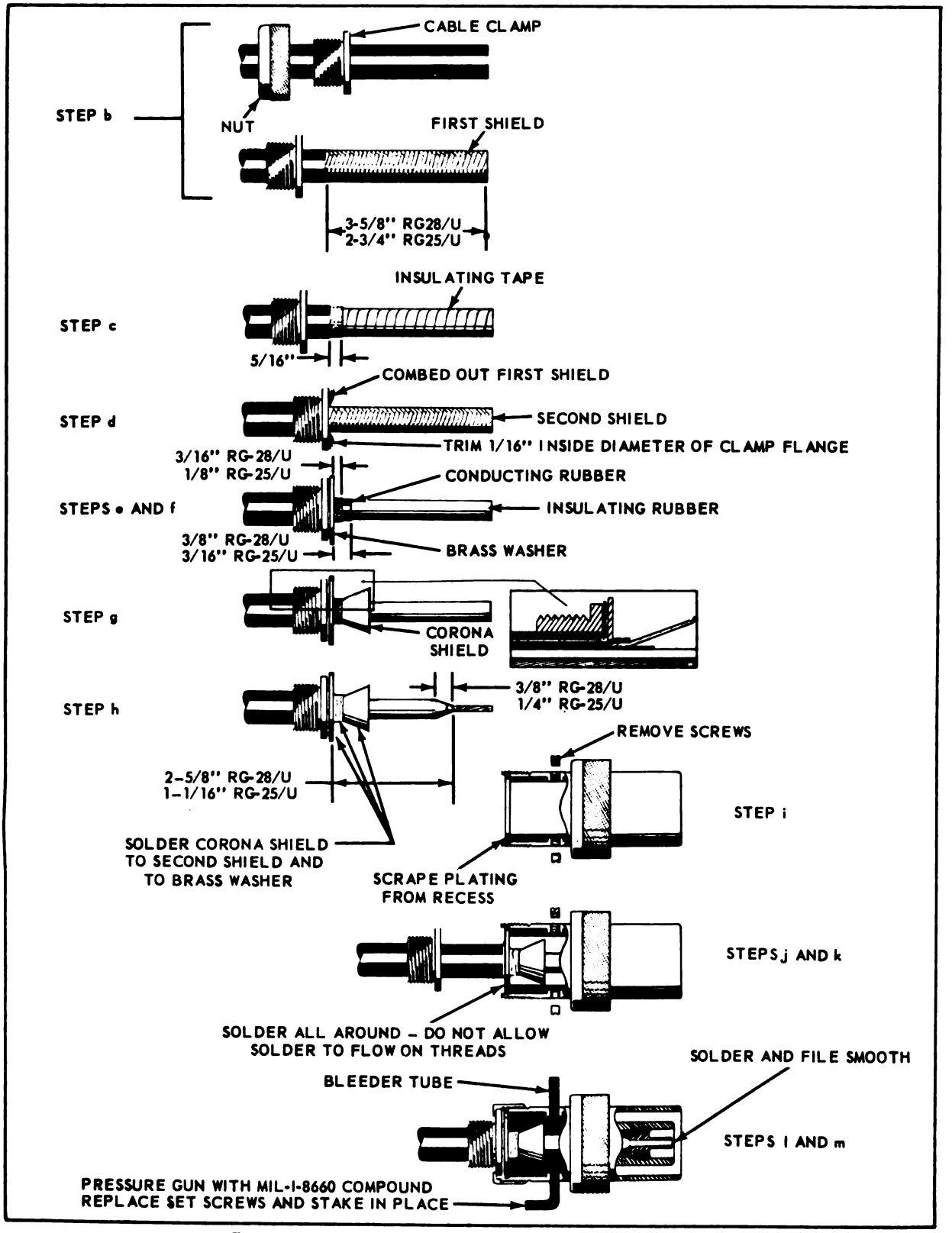


Figure 4-31. Assembly of Ceramic Insert Pulse Connector

CAUTION

Do not nick shield.

Slide cable clamp forward against fanned-out first shield. Trim shield strands 1/16 inch below diameter of cable clamp flange.

e. Slide brass washer carefully over second shield against fanned-out shield. Remove second shield to 3/16 inch from brass washer for RG-28/U cable, and 1/8 inch for RG-25/U cable, exposing conducting rubber.

f. Remove layer of conducting rubber to 3/8 inch from face of brass washer for RG-28/U cable and 3/16 inch for RG-25/U cable by making small slit at end of cable core, and removing conducting rubber with dull knife. Scrape insulating rubber underneath to remove any traces of conducting rubber.

CAUTION

Do not damage insulating rubber.

g. Slide corona shield over conducting rubber and under second shield until straight part of corona shield enters hole in brass washer approximately 1/16 inch.

h. Solder second shield to brass washer and to corona shield. Remove excess flux. Remove insulating rubber and conducting rubber underneath it to 2-5/8 inches from face of brass washer, for RG-28/U cable and 1-1/16 inches for RG-25/U cable exposing center conductor. Taper rubber down to conductor 3/8 inch for RG-28/U or 1/4 inch for RG-25/U. Tin center conductor. Remove excess flux.

i. Scrape nickel plating from recess of plug into which brass washer fits. Remove set screws.

j. Slide cable assembly into plug body, allowing cable clamp to slide back on cable. Solder brass washer to recess in plug by flowing solder into space between washer and groove. Remove excess flux.

k. Slide cable clamp against washer, and nut onto plug body. Start nut by hand and tighten with spanner wrench. Hold plug with strap wrench to prevent it from turning.

l. Cut off excess conductor protruding beyond contact pin. Solder conductor to contact by flowing solder down into hole. Leave drop of solder on end of contact and file smooth. Remove excess flux.

m. Insert bleeder tube in top hole, so it is vertical. Insert pressure gun in lower hole and fill plug cavity with Military Specification MIL-I-8660 compound until material oozes from bleeder tube. Replace set screws and stake with prick punch.

4–48. ATTACHING RUBBER INSERT PULSE CONNECTORS TO COAXIAL CABLE. When attaching rubber insert pulse connectors to coaxial cable (see figure 4–32) follow this procedure:

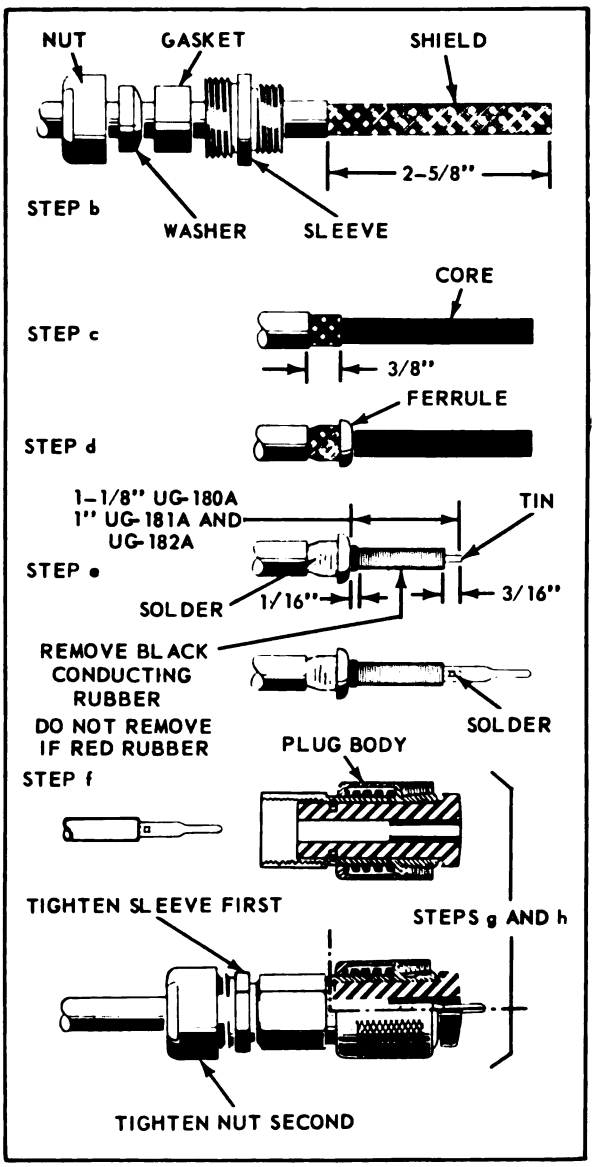


Figure 4–32. Assembly of Rubber Insert Pulse Connector

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

a. Disassemble nut, washer, gasket, sleeve and ferrule from plug or jack body. See figure 4–30.

b. Slide nut, washer, gasket, and sleeve in that order onto cable jacket. Remove 2-5/8 inches of outer jacket exposing shield. See figure 4–8.

CAUTION

Do not nick shield.

c. Cut shield(s) to 3/8 inch from cut edge of outer jacket, exposing cable core.

CAUTION

Do not nick or cut cable core.

d. Push ferrule over cable core and under shield(s).

e. Solder shield(s) carefully to ferrule all around its circumference. Be sure solder flows through to all shields. If it is necessary to solder shields separately, fold back outer shield. Solder inner shield, then bring forward outer shield and solder separately on top of inner shield. After solder has cooled, grasp cable in left hand, ferrule in right hand, and give several quick pulls to remove any slack in shield(s). Remove excess flux. Remove cable core with sharp square cut, leaving 1-1/8 inch from ferrule for connection to UG-180A/U, and one inch from ferrule for connection to UG-181A or 182A/U. Trim center conductor to 3/16 inch and tin.

Note

Cable RG-25A/U, 64A/U, 78/U and 88A/U have a thin layer of *red* insulating rubber over the cable core. Do not remove this layer. Cables RG-25/U and RG-64/U have a thin layer of *black* conducting rubber over the cable core. Remove this layer to 1/16 inch from ferrule very carefully with a sharp knife.

CAUTION

Do not nick or cut cable core.

f. Tin inside of contact (male or female) as shown in figure 4–11. Slip contact over center conductor so that contact butts flush against cable core. Solder, using a clean, well tinned soldering iron; contact must still be flush against cable core after solder has cooled; it it is not, remake the joint. See figure 4–12. Remove excess flux.

CAUTION

Be sure that correct contact is used; a male contact always goes into a plug body, and a female contact always goes into a jack body.

g. Push cable core into plug or jack body as far as it will go. Insert sleeve and tighten as far as it will go against ferrule, holding body with wrench so it will not turn. (See figure 4–13).

h. Insert gasket, then washer into sleeve. Install nut on sleeve and tighten until gasket deforms around cable to hold it securely.

4–49. TNC SERIES CONNECTORS.

4–50. TNC CONNECTOR TYPES. There is only one version of TNC connector. It consists of a body assembled to coaxial cable by means of a clamp nut, gasket and braid clamp. See figure 4–33. Table 4–7 lists the more common connectors in the TNC series and shows the coaxial cables associated with each. These connectors do not carry a military number.

4–51. ATTACHING TNC CONNECTORS TO COAXIAL CABLE. When attaching TNC connectors to coaxial cable (see figure 4–34), follow this procedure:

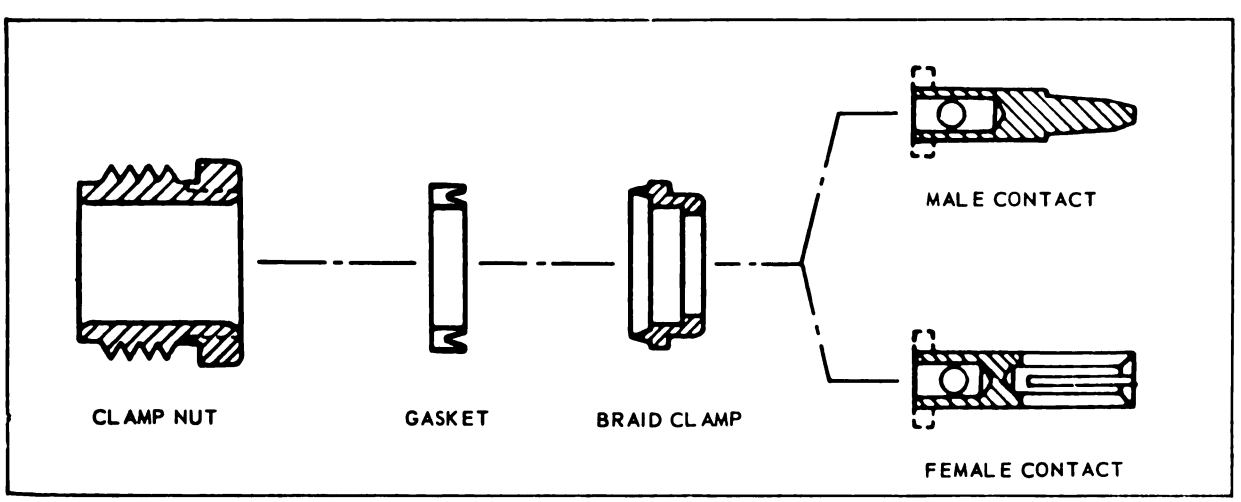


Figure 4–33. TNC Connectors – Exploded View

TABLE 4–7

TNC Series Connectors with Associated Cables

Plug		Jack		Panel Jack		Cable RG-
IPC	King	IPC	King	IPC	King	
79875	KA51-03	79600	KA31-02	79425	KA11-04	55/U, 58/U
79525	KA51-02	79500	KA31-03	79925	KA11-03	59/U

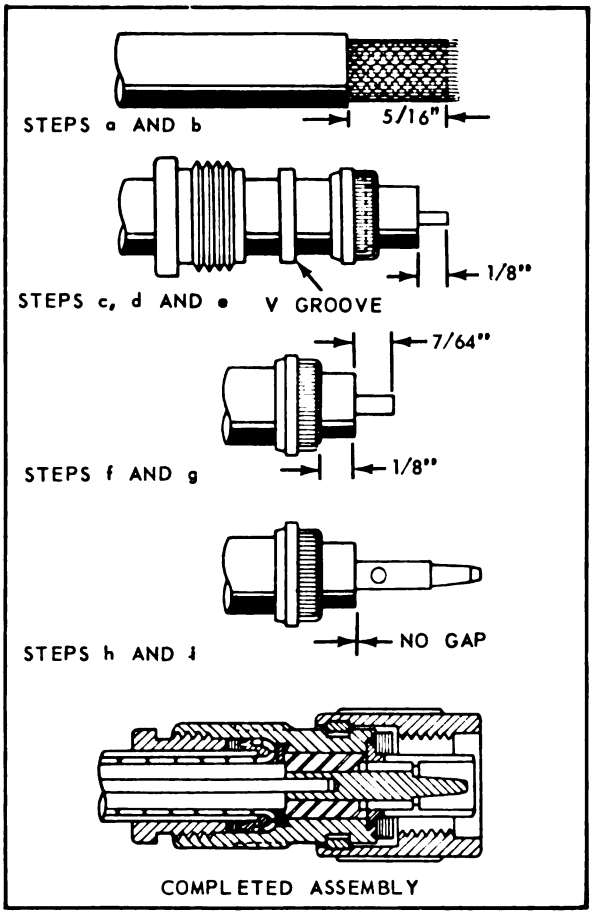


Figure 4–34. Attaching TNC Connectors to Coaxial Cable

Note

While attaching connector, observe all general precautions and procedures listed in 4–9 through 4–25.

a. Remove 5/16 inch of outer jacket, exposing shield. See figure 4–8.

CAUTION

Do not nick shield.

b. Comb out shield. Take care to prevent breaking shield strands.

CAUTION

Do not nick center conductor.

c. Disassemble nut, grooved gasket and sleeve clamp from plug or jack body. See figure 4–33.

d. Taper shield toward center conductor, and slide nut and grooved gasket in that order over tapered shield onto jacket. Then slide sleeve clamp over tapered shield until inside shoulder of clamp butts flush against cut end of jacket.

e. Comb shield back smoothly over clamp and trim with scissors even with tapered part of clamp.

f. Trim dielectric to 1/8 inch from shield, and cut off center conductor to 7/64 inch from edge of dielectric.

g. Tin center conductor as shown in figure 4–10.

h. Slide contact over center conductor until contact butts flush against dielectric. Solder contact to center conductor. (See figure 4–12).

CAUTION

Make sure that correct contact is used; a male contact always goes into a plug body, and a female contact always goes into a jack body.

i. Push cable assembly into connector body as far as it will go. Make sure gasket is properly seated, with sharp edge of sleeve entering gasket groove. Tighten nut holding the body stationary. (See figure 4–13).

4–52. SC CONNECTORS. SC connectors are identical with the C connectors except for the coupling means. The procedure for attaching SC connectors to coaxial cable is the same as for C connectors. See 4–35 and 4–36, and figure 4–20. These connectors do not carry a military number.

4–53. MINIATURE RF CONNECTORS.

4–54. MB MINIATURE CONNECTOR SERIES. These are small, lightweight, bayonet type, quick connect/disconnect connectors, used with small RF cables where peak voltage is not more than 500 volts. These connectors do not carry a military number. No soldering is required in the assembly of plugs to solid center conductors, such as RG58/U, 59/U, 62/U, 71/U and 141/U. All jacks require soldering. Table 4–8 lists the more common connectors in the MB series and shows the coaxial cables associated with each. These connectors consist of a plug or jack body assembled to coaxial cable with clamp nut, braid clamp and insulator bushing. (See figure 4–35)

4–55. ATTACHING MB CONNECTORS TO COAXIAL CABLE. The assembly procedure differs according to the cable used. For assembly to cables RG58/U and RG141/U, the procedure is as follows: (See figure 4–36)

a. Remove cable jacket to A dimension given in table 4–9. Insert clamp nut over cable jacket and braid clamp over braid wire.

b. Comb out braid wire, form back over braid clamp and trim to length. Cut off cable dielectric to dimension C in table 4–9, and tin exposed conductor. If solderless contact is used, omit tinning.

c. Insert contact over conductor. The end of the solderless contact with the shortest slot is inserted over the conductor. If solder contact is used, solder it to the conductor, and remove excess solder from the outside of the contact.

d. Insert assembly minus clamp nut into body and rotate slightly to make sure braid clamp is seated. When assembling straight plugs insert insulator over contact before assembly into body. Thread clamp nut into body and tighten nut, holding body stationary.

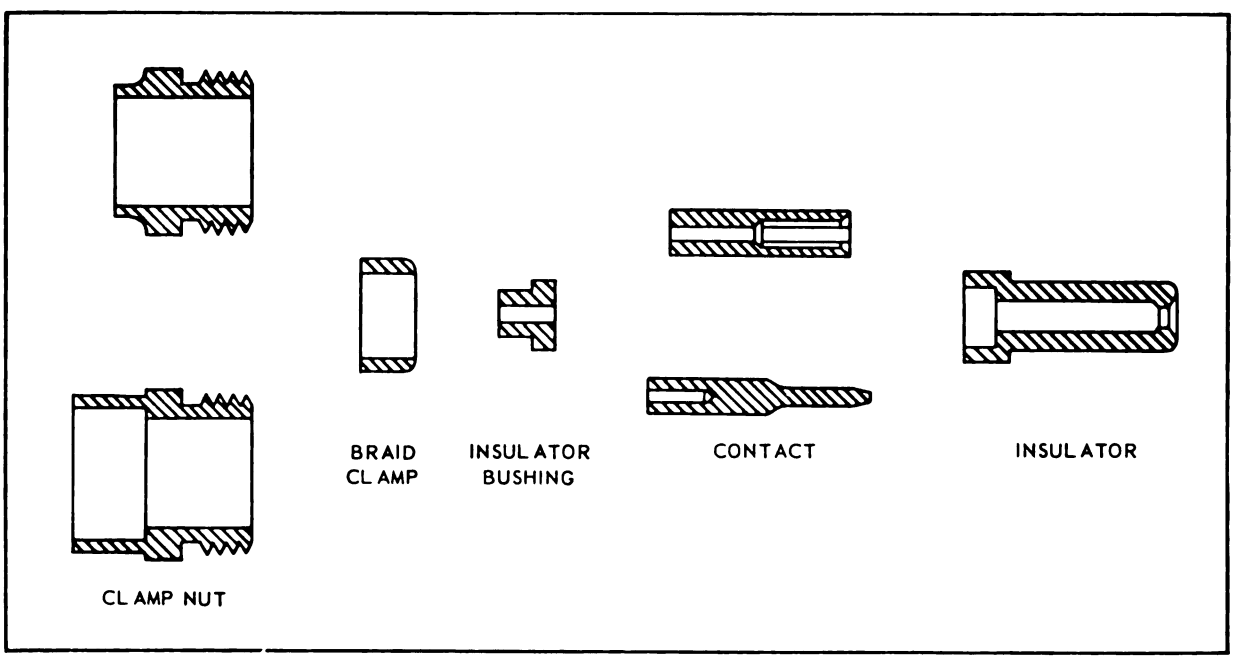


Figure 4–35. MB Connectors – Exploded View

TABLE 4–8

MB Series Connectors with Associated Cables

Plug (IPC)	Angle Plug (IPC)	Jack (IPC)	Panel Jack (IPC)	Cable RG-
45000 45050	53000	46700	46300	58/U, 141/U
45025 45550	53500	46775	46325	59/U, 62/U,

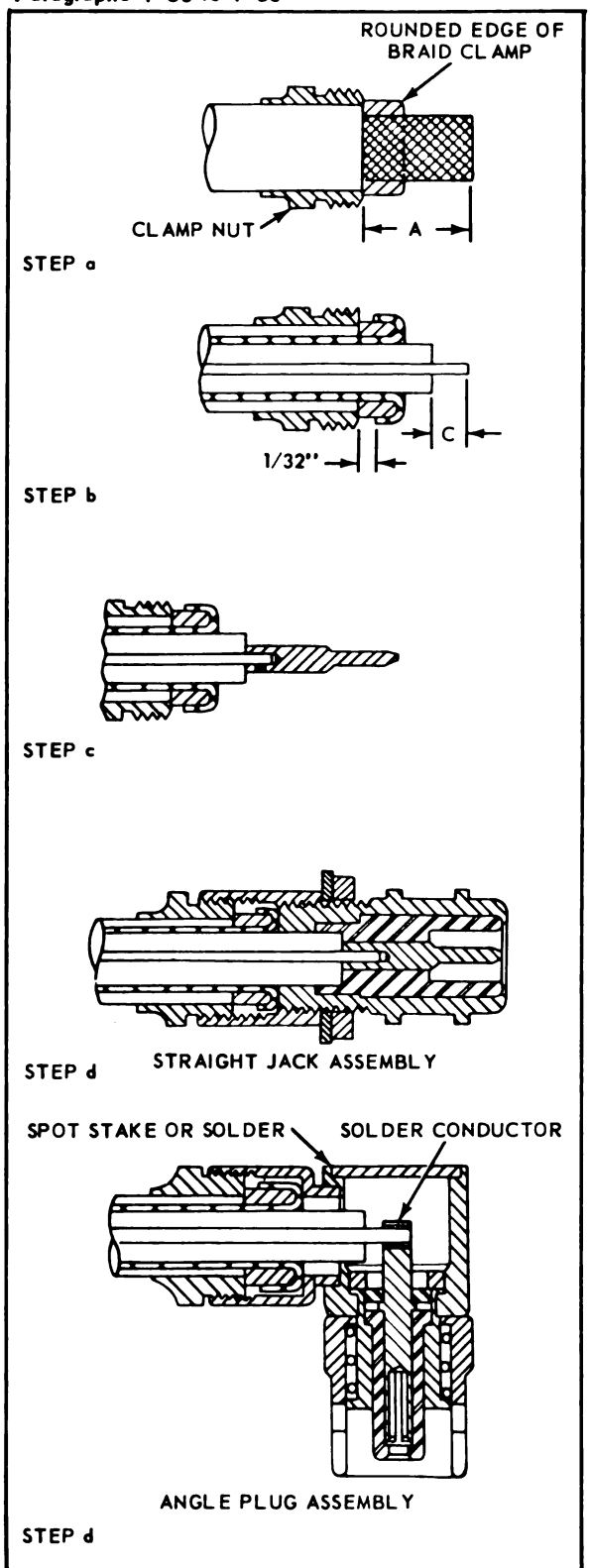


Figure 4–36. Attaching MB Connectors to Coaxial Cable

For assembly to cables RG59/U, and 62/U the procedure is as follows:

a. Remove cable jacket to dimension A in table 4–9. Insert clamp nut over cable so that internal shoulder seats against end of cable jacket. Insert braid clamp over wire.

b. Comb out braid wires, form back over braid clamp, and trim to length. Cut off cable dielectric to dimension C in table 4–9, and tin exposed conductor. If solderless contact is used omit tinning.

c. Insert contact over conductor. The end of the solderless contact with the shortest slot is inserted over the conductor. Insert insulator bushing over contact if cable RG62/U is being used. If solder contact is used, solder it to the conductor, and remove excess solder from the outside of the contact.

d. Insert insulator over contact. Insert assembly minus clamp nut into body and rotate slightly to make sure braid clamp is seated. Thread clamp nut into body and tighten nut, holding body stationary.

e. Right angle jacks or plugs: Strip cable jacket and dielectric, install parts and form braid as instructed in steps a and b above.

f. Tin conductor, and insert assembly into body.

g. With cap removed, solder the conductor in slot of angle plug contact.

h. Insert cap, and spot solder or spot stake.

4–56. SUBMINIATURE RF CONNECTORS.

4–57. SUBMINIATURE RF CONNECTORS (Amphenol #27 Series). These connectors are very small, lightweight connectors designed for use with RG-174/U miniaturized coaxial cable, where peak voltage does not exceed 500 volts. Coupling is either of the screw thread type, or the push-on type. The connectors consist of a plug or jack body assembled to coaxial cable with a sleeve and an insulator. See figure 4–37. The assembly is crimped into the body, and a vinyl boot shrunk on for cable strain relief. Table 4–10 lists types of #27 series connectors commonly used in aircraft. These connectors do not carry a military number.

4-58. ATTACHING SUBMINIATURE RF CONNECTORS TO COAXIAL CABLE. When attaching subminiature RF connectors to coaxial cable, follow this procedure: (See figure 4–38).

a. Dilate the boot and slip it over the cable. The boot will remain dilated for approximately five minutes.

b. Trim jacket to dimension A in table 4–10.

CAUTION

Do not nick braid.

TABLE 4-9

Stripping Dimensions for Coaxial Cable Assembled to MB Connectors

	Connector Part (IPC)	to RG- /U Cable	Stripping Dimensions A	C
Plugs	45000	58, 141	1/4	5/64
	45025	59, 62	7/16	5/64
	45050	58, 141	1/4	5/64
	45550	59, 62	7/16	5/64
Jacks	46300	58, 141	1/4	3/32
	46325	59, 62	1/2	3/32
	46700	58, 141	1/4	3/32
	46775	59, 62	1/2	3/32
Angle Plugs	53000	58, 141	3/8	7/64
	53500	59, 62	3/8	7/64

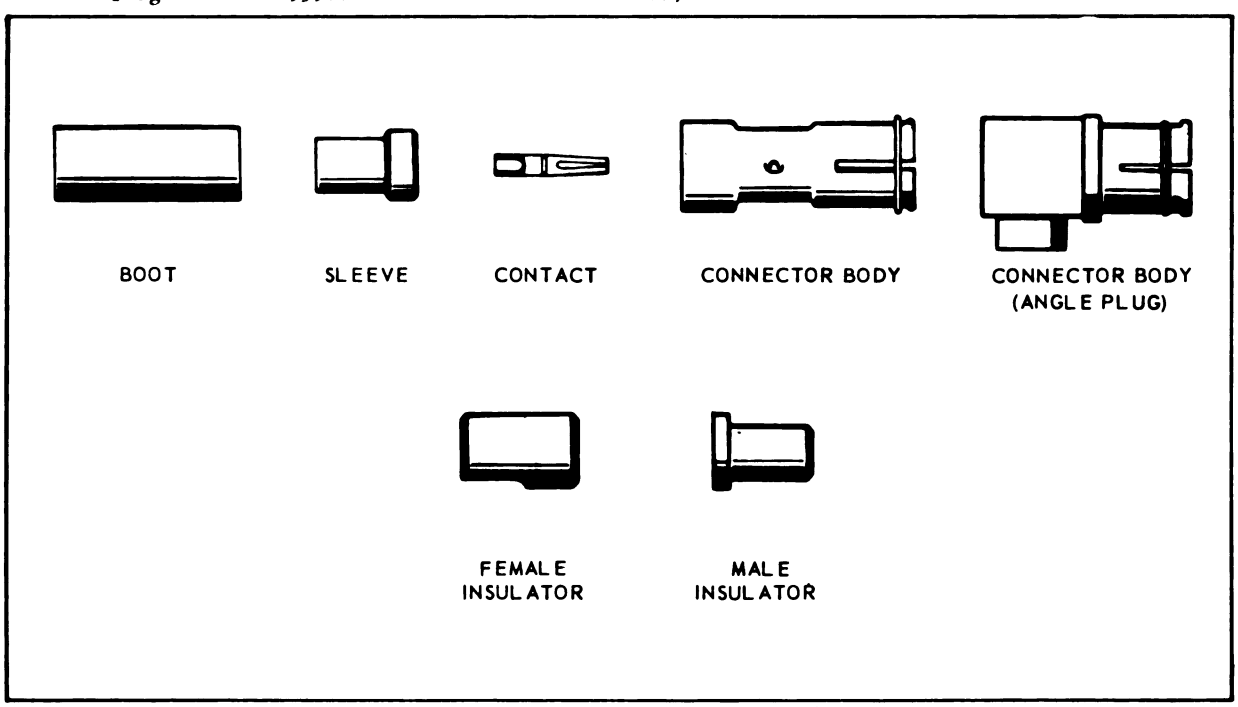


Figure 4-37. Subminiature RF Connector – Exploded View

TABLE 4-10

Stripping Dimensions and Crimping Tool Positions for Subminiature RF Connectors

Body Type	A Inches (+ 0 −1/64)	B Inches (Max)	Position in Tool 27-900 Figure No.
Straight Plug	23/64	1/16	4-39 a
Jack, Push-on	3/8	1/16	4-39 b
Jack, Screw-on	3/8	.082	4-39 c
Bulkhead Jack	3/8	.082	4-39 c
Angle Plug	25/32	7/64	4-39 d

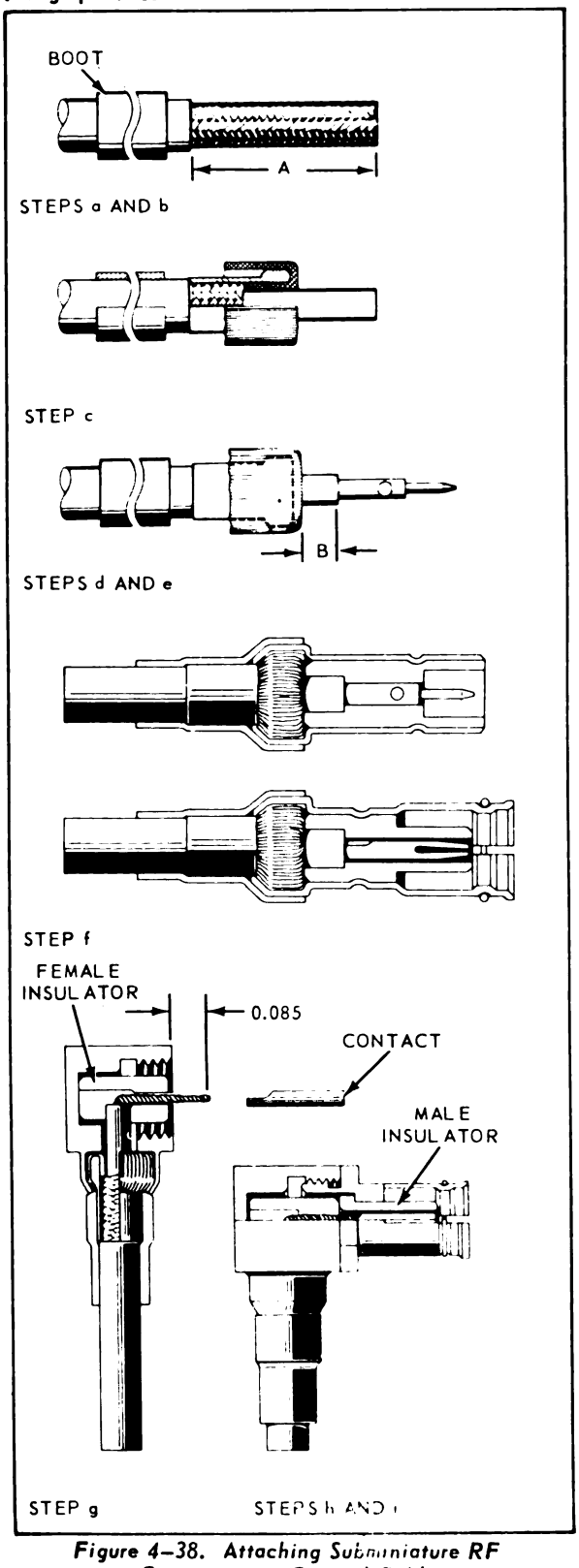


Figure 4–38. Attaching Subminiature RF Connectors to Coaxial Cable

c. Slip sleeve over braid against cable jacket. Fold braid back over the sleeve and comb out so it lays even without overlapping.

d. Trim dielectric to dimension B in table 4–10. Tin exposed center conductor, and clean off excess solder.

e. Straight plugs and jacks: Slip contact over center conductor so that it butts flush against cut end of dielectric. Solder contact to conductor, and remove excess solder from outside of contact.

CAUTION

Avoid overheating during soldering, so as not to deform dielectric.

f. Slip cable assembly into body and trim off excess braid protruding beyond body end. Crimp the assembly securely (see 4–59 for detailed crimping instructions), and pull boot over body as shown.

g. Angle plugs: Unscrew front part of body. Follow procedure of steps a through d above. Then thread cable through back part of body as shown and crimp. Thread female insulator over conductor and insert into body. Holding the female insulator in place in the body, pull the cable as far forward as possible to remove all slack. Trim conductor to .085 inch maximum.

h. Slip contact over conductor and butt contact flush against the female insulator. Solder contact to conductor, and remove excess solder.

i. Place male insulator over the contact, and screw the front body part into back body and tighten with end wrench.

4–59. CRIMPING PROCEDURE FOR SUBMINIATURE CONNECTORS. Crimp subminiature connector bodies as follows:

a. Open jaws of tool 27-900 by loosening nut and pulling down lock screws (see figure 4–39). Place the connector assembly in jaws, and set optimum distance between jaws for each assembly by means of the travel limit screw. Refer to connector placement figure 4–39 a, b and c for straight plugs and jacks, and figure 4–39d for angle plugs.

b. Lock jaws by pulling lock screws up, and tighten nut.

c. Squeeze handles to crimp.

d. Release handles to open jaws, and remove crimped assembly. Trim off any excess braid protruding beyond end of body.

e. Slip boot over body end.

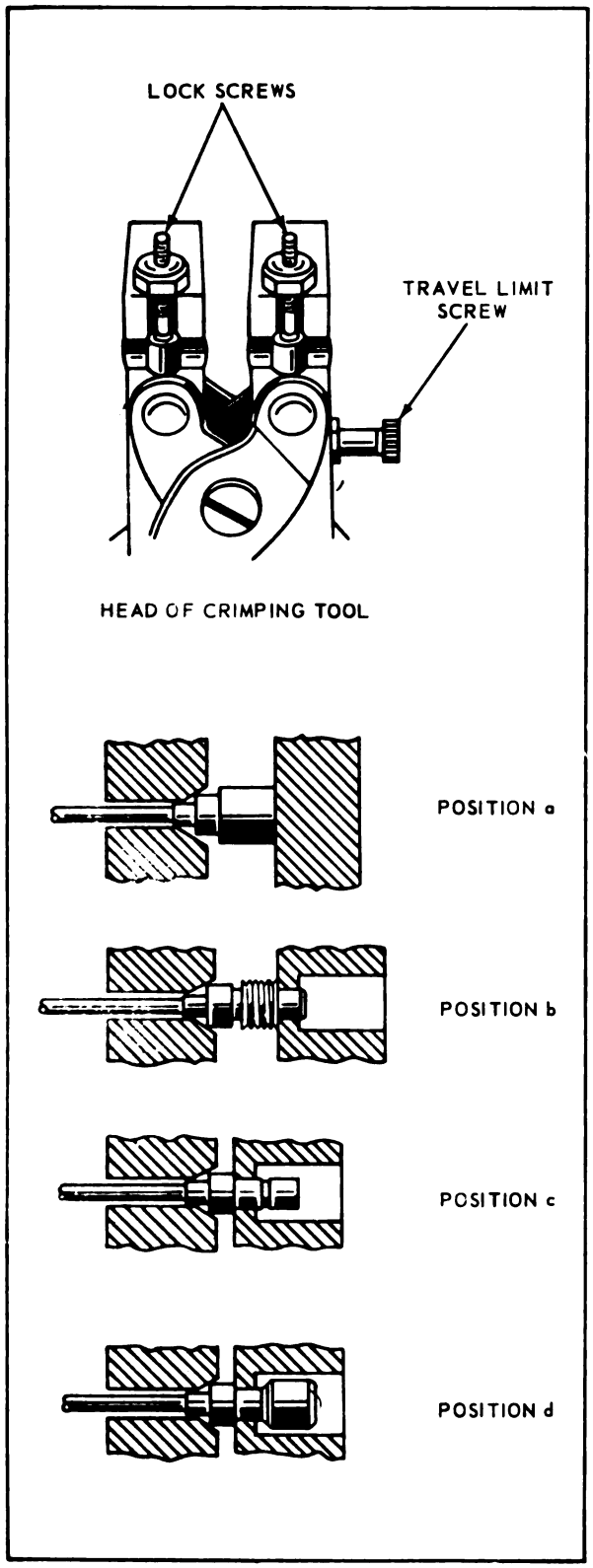


Figure 4–39. Crimping Subminiature RF Connectors

4–60. RF CONNECTORS USED IN FUEL QUANTITY INDICATING SYSTEMS. Because of their transmission line efficiency, RF connectors are often used in aircraft fuel quantity indicating systems. The connectors most commonly used for this purpose are of two types. One is similar to the standard BNC connector; typical of these are the 163 series made by Avien, and the Liquidometer 9100 series. The second type are miniature RF connectors; the Nu-Line 1200 series (MIL-C-25516), and Liquidometer S62 and S63 are typical. These connectors are designed to be used with coaxial cable, but they are also frequently used with standard shielded or unshielded wire; they do not carry a military number.

4–61. ASSEMBLING BNC TYPE FUEL QUANTITY INDICATING CONNECTORS. When assembling BNC type RF connectors, use the following procedure:

a. Assembly of Avien 163-088 and 163-089 connectors to RG-58A/U coaxial cable: See figure 4–40.

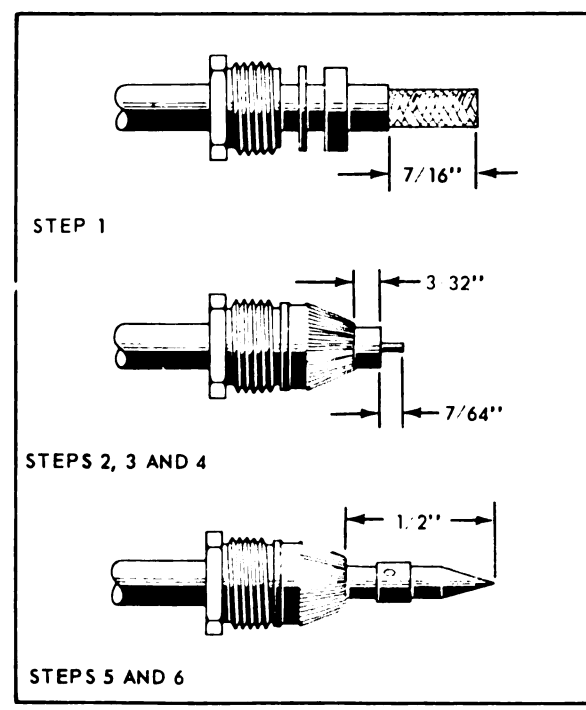


Figure 4–40. Attaching Avien 163-088 and 163-089 Connectors to Coaxial Cable

1. Slide nut, washer and gasket onto cable. Strip outer jacket 7/16 inch, taking care not to nick the braid. Slide the clamp over the braid so it rests flush against the cut end of the jacket.

2. Comb out braid and fold it back over the clamp, and trim the braid even with edge of clamp.

3. Strip the dielectric 3/32 inch from edge of clamp.

4. Cut exposed conductor to 7/64 inch.

5. Slide contact onto conductor, and check that there is no exposed conductor between the insulation and the contact solder hole. Check that the distance from the braid to the end of the contact is 1/2 inch as shown in figure 4-40.

6. Tin the conductor and the solder hole, and solder the contact to the conductor. Remove any excess solder.

7. Push assembly into connector body, screw nut into body and tighten.

b. Assembly of Avien 163-07 and 163-027 connectors to AN No. 20 unshielded wire: (See figure 4-41).

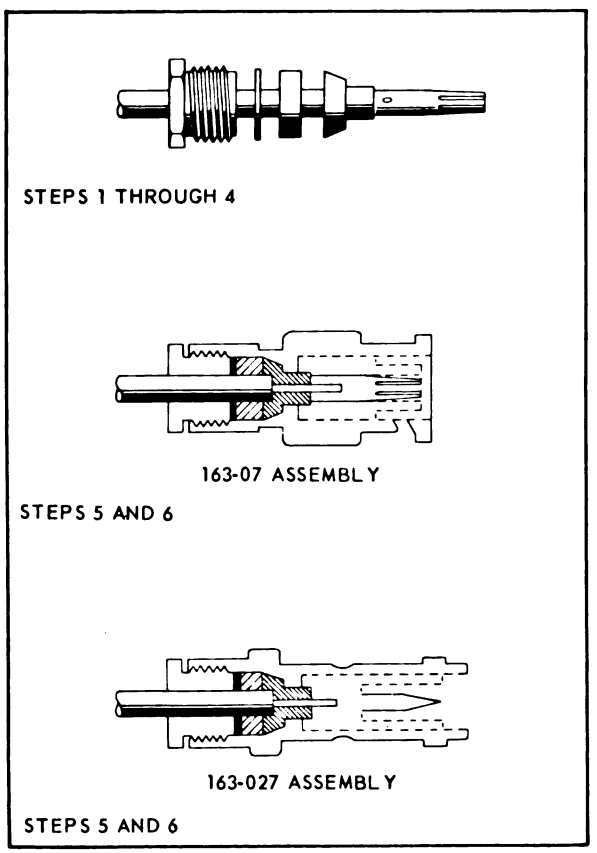


Figure 4-41. Attaching Avien 163-07 and 163-027 Connectors to Unshielded Wire

1. Strip wire to expose 1/4 inch of conductor, and tin the stripped wire. Tin inside of contact.

2. Slide nut, washer and gasket over the wire. Install TFE clamp over the wire, so that the inside shoulder of the clamp butts against the cut insulation.

3. Slide contact over the wire so that it butts against end of the clamp. While doing this, hold the insulation firmly in place against the clamp shoulder.

4. Solder the contact to the conductor, and remove any excess solder.

5. Insert the assembly into the connector body. The contact end should be flush with the end of the TFE clamp, but a recess of 1/32 inch maximum is acceptable.

6. Tighten nut, holding the body stationary.

c. Assembly of Liquidometer 9100 series connectors to RG-58/U coaxial cable: (See figure 4-42).

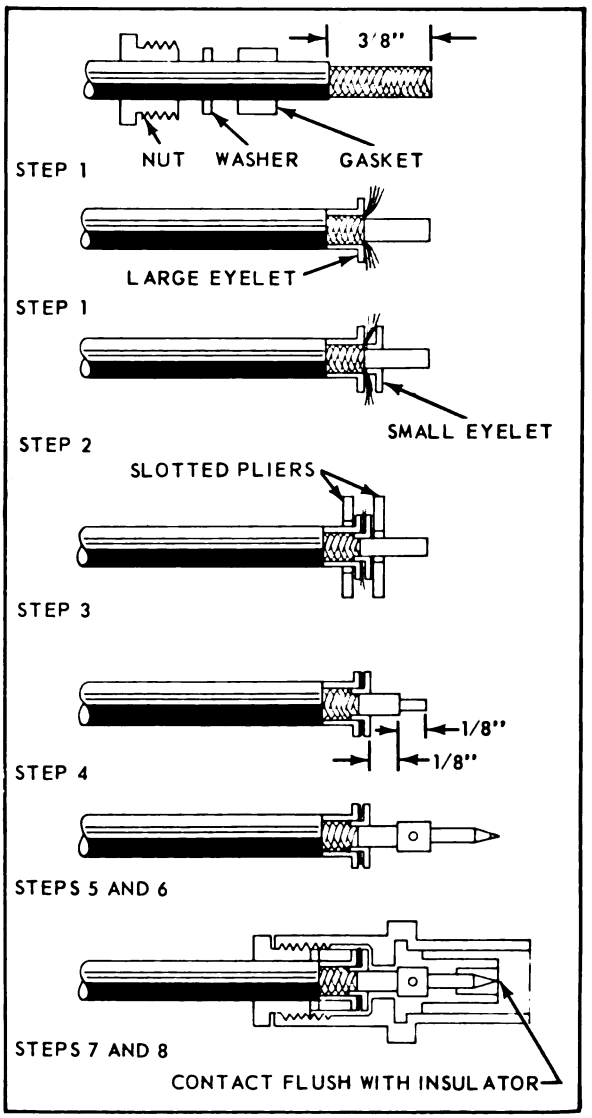


Figure 4-42. Attaching Liquidometer 9100 Series Connectors to Coaxial Cable

1. Slide nut, washer and gasket over the cable; strip outer jacket 3/8 inch, taking care not to nick the braid. Slide the large eyelet over the braid so that it butts against the cut end of the jacket.

2. Comb out the braid up to the large eyelet, and slide the smaller eyelet over the dielectric.

3. Clamp the braid between the two eyelets with special slotted pliers as shown, (see figure 4–42). Trim off excess braid.

4. Cut dielectric 1/8 inch from the small eyelet, and cut off the exposed conductor to 1/8 inch.

5. Tin the exposed conductor and the inside hole of the contact.

6. Slide the contact onto the conductor and solder. Remove any excess solder.

7. Seat contact and eyelets into connector body and install the gasket firmly against the eyelets. Insert washer firmly against the gasket.

8. Screw nut into connector body and tighten, holding connector body stationary. Tighten to 30 to 35 inch pounds torque.

4–62. ASSEMBLING MINIATURE RF FUEL QUANTITY INDICATING CONNECTORS. When assembling miniature RF connectors to wire or cable, use the following procedure:

a. Assembly of Nu-Line 1200 Series coaxial connectors to coaxial cable: (See figure 4–43).

1. Remove 1/2 inch of outer jacket, exposing shield.

2. Slide nut, washer and gasket, in that order, onto outer jacket.

3. Screw threaded braid clamp over jacket as shown.

4. Comb out braid, and fold braid back over braid clamp, without overlap.

5. Slide braid clamp sleeve (large ID toward gasket) over braid, and trim off excess braid with scissors. Install O-ring as shown.

6. Place contact retainer firmly over dielectric, and strip off dielectric flush with contact retainer, exposing center conductor.

7. Cut off center conductor .08 inch from cut end of dielectric.

8. Slide contact, male or female, over center conductor, so that contact butts flush against dielectric.

9. Solder contact to center conductor; contact must still be flush against dielectric after soldering.

10. Slide cable assembly into connector body as far as it will go. Torque nut to approximately five inch pounds.

b. Assembly of Liquidometer S62 and S63 series connectors to RG-58/U coaxial cable (See figure 4–44).

1. Slide nut and bushing back over cable. Cut outer jacket to "A" dimension in table 4–11, being careful not to nick braid.

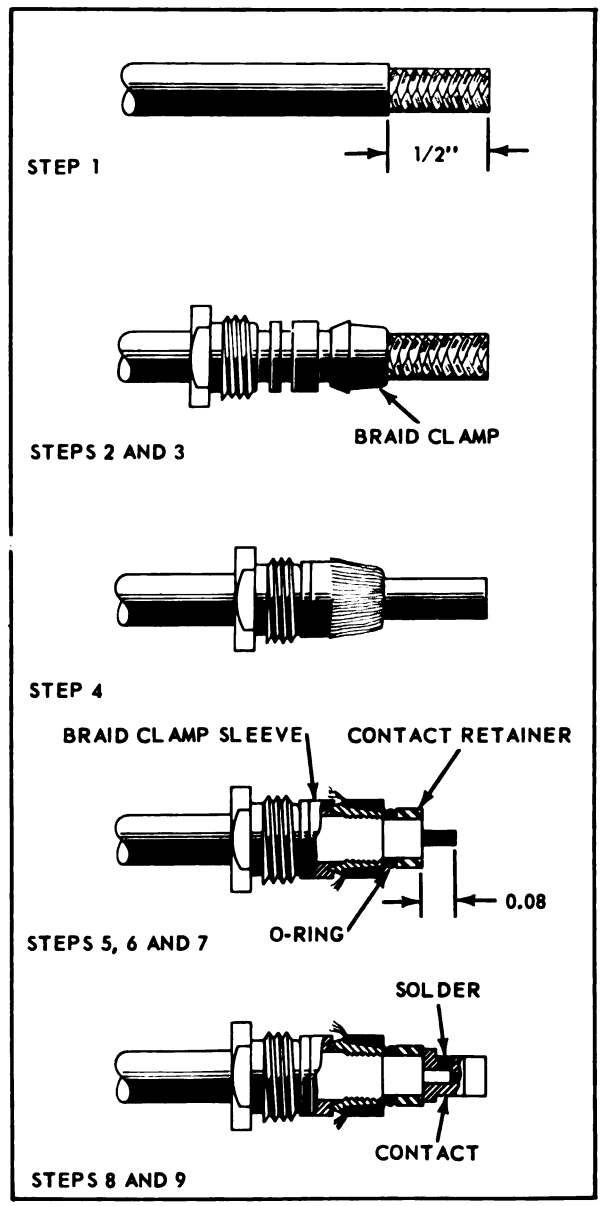


Figure 4–43. Attaching Nu-Line 1200 Series Connectors to Coaxial Cable

TABLE 4–11

Stripping Dimensions for Coaxial Cable Assembled to Liquidometer S62 and S63 Series Connectors

Connector (Liquidometer Number)	Stripping Dimension A
S62-1 and -4	11/32 inch
S62-2 and -3	5/16 inch
S63-1 and -4	5/16 inch
S63-2 and -3	5/32 inch

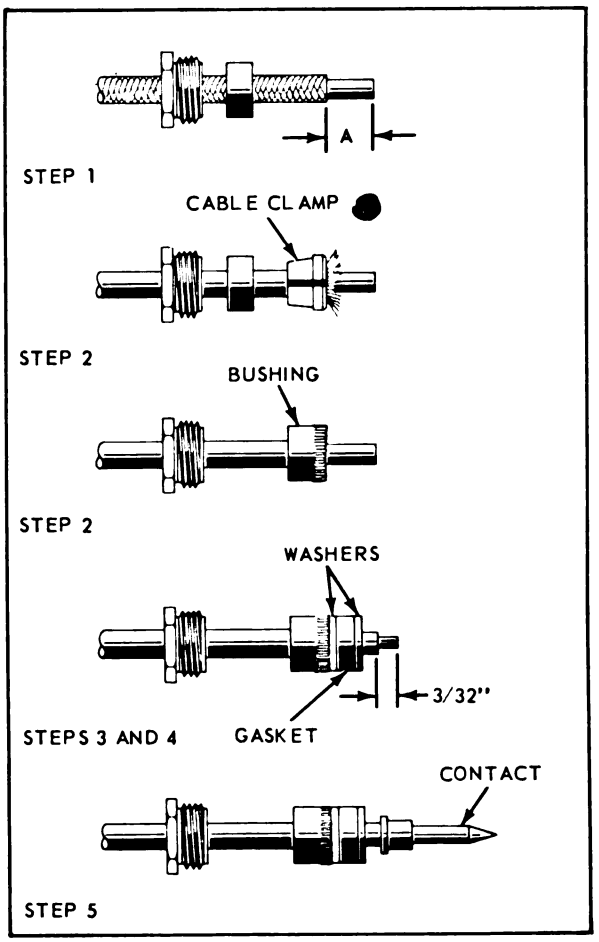


Figure 4–44. Attaching Liquidometer S–62 and S–63 Connectors to Coaxial Cable

2. Place the two halves of the cable clamp over the cable, lining up front (large) end of clamp with cut end of outer jacket. Slide bushing over tapered end of clamp. Compress bushing over cable clamp with special pliers as far as it will go.

Note

Special pliers No. TJF-107 are available from connector manufacturer.

3. Comb braid back over clamp and trim braid around edge of clamp.

Note

Omit next step (4) when using connectors S62-4 and S63-4.

4. Slide washer, gasket and second washer over dielectric and push up to cable clamp. Cut off dielectric to expose 3/32 inch of conductor, and tin conductor.

5. Slide contact over conductor and solder. Remove any excess solder.

6. Slide assembly into plug or jack body until contact shoulder seats on insulator. Screw clamp nut into body, using a torque of 15 inch pounds.

SECTION V

SOLDERLESS TERMINATIONS AND SPLICES

5–1. INTRODUCTION.

5–2. GENERAL. Electric wires are terminated with solderless terminal lugs to permit easy and efficient connection to and disconnection from terminal boards, busbars, and other electrical equipment. Solderless splices join electric wires to form permanent continuous runs.

5–3. SCOPE. This section describes recommended methods for terminating copper and aluminum wires, using solderless terminal lugs. It also describes recommended methods for permanently joining (splicing) wires, using solderless splices. (Termination of thermocouple wires is covered in section VII).

5–4. REFERENCE SPECIFICATIONS, DRAWINGS AND DOCUMENTS.

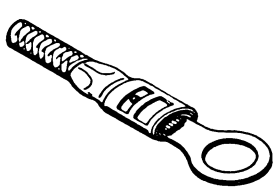
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Non-Rigid
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-T-7099	Terminals, - Lug and Splice, Crimp Style Aluminum, for Aluminum Aircraft Cable
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
MIL-T-7928	Terminals, Lug and Splice, Crimp Style, Copper
MIL-I-23053	Insulation Sleeving, Electrical, Flexible, Heat Shrinkable
MS20659	Terminals, Lug, Crimp Style, Copper Uninsulated, Class I
MS23002	Dies, MS25441 Crimping Tool, for use with MS25036, Size 8 through 4/0 Terminals
MS23003	Gages for MS23002 Crimping Dies
MS25036	Terminal, Lug, Crimp Style, Copper Insulated, Class I
MS25037	Crimping Tool, Hand, for Copper Insulated Terminal
MS25181	Splice, Electric, Permanent, Crimp Style, Copper, Insulated, Class I
MS25189	Terminal, Lug, Flag Type, Crimp Style, Copper
MS25340	Gages, for MS25037 Crimping Tool, Electric Terminal
MS25435	Terminal-Lug, Crimp Style, Straight Type for Aluminum Aircraft Wire
MS25436	Terminal-Lug, Crimp Style, 90 Deg. Upright Type, for Aluminum Aircraft Wire
MS25437	Terminal-Lug, Crimp Style, Left Angle Type, for Aluminum Aircraft Wire
MS25438	Terminal-Lug, Crimp Style, Right Angle Type, for Aluminum Aircraft Wire
MS25439	Splice, Permanent, Crimp Style, 2-Way Type, for Aluminum Aircraft Wire
MS25441	Tool, Crimping, Electric, Hydraulic, For Wire Terminals Sizes 8 thru 4/0
MS25442	Dies, for MS25441 Electric, Hydraulic Crimping Tool
MS25472	Gages, for MS25442 Crimping Dies
MS25494	Tool, Manual, Hydraulic, for Crimping Electric Wire Terminals
AN3427	Crimping Tool, Electric Cable Terminal, Hand
AND10160	Indentors and Nests - Copper Electric Terminal, Power Operated Press
EMB 14-55	Aircraft Electrical Aluminum Wire and Terminals, Installation Practices for

5–5. DESCRIPTION. Solderless terminal lugs and splices are copper or aluminum, and are pre-insulated or uninsulated depending on the application. Terminal lugs and splices for high temperature applications are silver-or nickel-plated copper, and are insulated with TFE or a similar material.

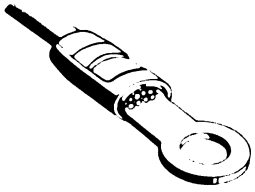
Note

Use copper terminations only on copper wire. Use aluminum terminations only on aluminum wire.

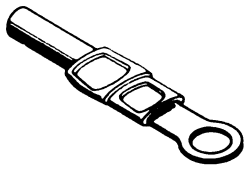
Terminal lugs are available in four styles: straight, 90 degree upright, angle and flag, for use under different space conditions. Figure 5–1 shows typical terminal lugs and splices. Terminal lugs and splices are crimped to wires by means of hand or power crimping tools.



AMP

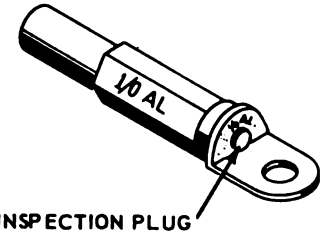


BURNDY



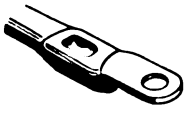
THOMAS & BETTS

a. PRE-INSULATED COPPER TERMINAL LUGS MS25036

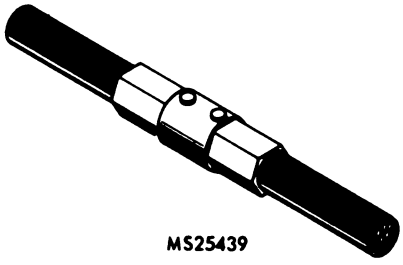


INSPECTION PLUG

MS25435



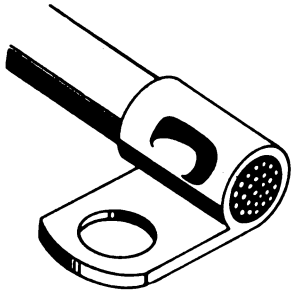
MS25021 (OBSOLESCENT)

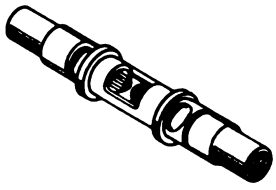


MS25439

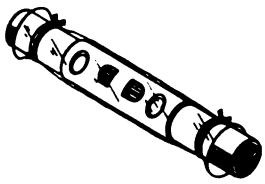
b. ALUMINUM TERMINAL LUGS

c. ALUMINUM SPLICE





PRE-INSULATED (MS25181)



UNINSULATED

d. FLAG TYPE COPPER TERMINAL LUG

e. COPPER SPLICES

Figure 5–1. Solderless Terminal Lugs and Splices

Power tools are portable or stationary (bench-mounted). Typical crimping tools are illustrated where they are mentioned in the procedures. Solderless terminal lugs and splices most commonly used are made by AMP, Burndy and T & B (Thomas and Betts); this section is therefore limited to these items.

5–6. Terminal lugs and splices, and the tools used to install them on wires, are divided into two classes, as follows:

Class 1 lugs and splices are those which meet all the requirements of the applicable Military Specification and Standard when installed with the specified crimping tools. Class 1 tools are those which meet all the requirements of the applicable Military Specification and Standard.

Class 1 tools are the only crimping tools supplied for military maintenance use.

Class 2 lugs and splices are those which are replaceable by Class 1 terminals, and which meet the performance requirements of the applicable Military Specification when installed with a tool recommended by the terminal manufacturer. Class 2 tools are those which will crimp terminals to meet the performance requirements of the applicable Military Specification.

Note

Class I tools, splices and lugs shall be used in all cases where so designated.

5–7. TERMINATING SMALL COPPER WIRES (SIZES No. 26 THROUGH No. 10).

5–8. PRE-INSULATED TERMINAL LUGS. Small copper wires, (sizes No. 26 through No. 10) are terminated with solderless pre-insulated straight copper terminal lugs conforming to Military Specification MIL-T-7928 and Military Standard Drawing MS 25036. As shown in figure 5–2, the insulation is part of the terminal lug and extends beyond its barrel, so that it will cover a portion of the wire insulation; this makes the use of an insulation sleeve unnecessary. In addition, pre-insulated terminal lugs have an insulation-grip (a metal reinforcing sleeve) beneath the insulation, for extra gripping strength on the wire insulation.

5–9. Pre-insulated terminals accommodate more than one size of wire; the insulation is color-coded, as shown in table 5–1, to identify the wire sizes that can be terminated with each of the terminal lug sizes.

5–10. CRIMPING TOOLS. Hand, portable power and stationary power tools are available for crimping terminal lugs. These tools crimp the barrel to the conductor, and simultaneously crimp the insulation grip to the wire insulation. Use the standard (Class 1) tool MS 25037 to crimp the standard (Class 1) copper terminal lugs MS25036. Use the crimping tools of each manufacturer for the non-standard (Class 2) terminal lugs of the same manufacturer. Crimping tools most commonly used are listed in table 5–2.

TABLE 5–1

Color Coding of Copper Terminal Lug Insulation

Color of Terminal Lug Insulation	To Be Used On Wire Sizes
Yellow	#26 - #24
Red	#22 - #20, #18
Blue	#16 - #14
Yellow	#12 - #10

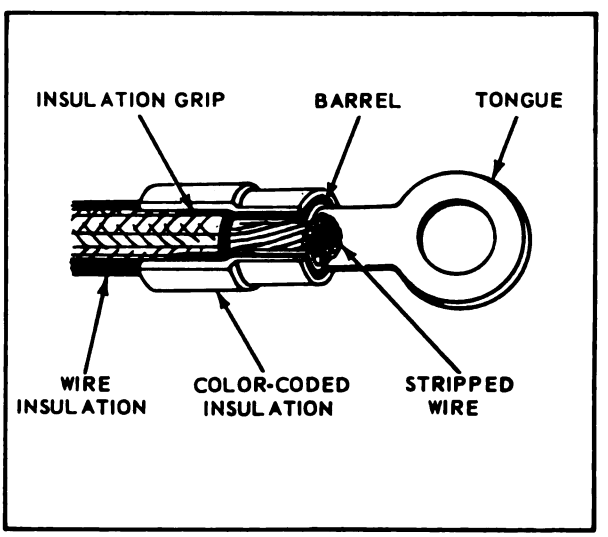


Figure 5–2. Pre-Insulated Terminal Lug-Cut-Away

5–11. HAND TOOL DESCRIPTION. MS25037 hand crimping tool has a self-locking ratchet which prevents the tool from opening until crimp is complete. This mechanism must never be disassembled since it insures proper crimping pressure. This tool has nests identified by color-coded arrows. (See figure 5–3).

5–12. HAND TOOL INSPECTION. The standard tool MS 25037 is checked by means of a gage for proper adjustment of crimping jaws. For good crimping results, this is done before each series of crimping operations. Return hand tools which are out of tolerance for repair. Check tools as follows:

(MS25340 gage is used to check this tool.)

1. Place the lower stop bar of MS25340-1 in the yellow nest and gage the red-blue upper nest with MS25340-3 "GO-No GO" gage.

2. Place the upper stop bar of MS25340-1 in the red-blue nest and gage the yellow lower nest with MS25340-2 "GO-No GO" gage.

TABLE 5-2

Copper Terminal Lugs (Small) and Crimping Tools

Wire Size Range and Color Code	Hand Tool	Portable Power Tools: Tool Number	Portable Power Tools: Insert Name and Number	Stationary Power Tools: Tool Number	Stationary Power Tools: Insert Name and Number
1. MS25036:					
#26 – #24, Yellow #22 – #18, Red #16 – # 14, Blue #12 – #10, Yellow	Standard Tool MS25037	- - - -	- - - -	- - - -	- - - -
2. AMP:					
#26 – #24, Yellow	- - - -	69005 69100	Head 47469 Head 46224	69011	Die 45155
#22 – #18, Red	- - - -	69005 69100	Head 47516 Head 47806	69011	Die 47498
#16 – #14, Blue	- - - -	69005 69100	Head 47517 Head 47807	69011	Die 47499
#12 – #10, Yellow	- - - -	69010 69100	Head 47518 Head 47808	69012	Die 47500
3. BURNDY:					
#26 – #24, Yellow	- - - -	M8ND Y8ND	Die Set N22HET-1	Y10NCP	Die Set R22HET-2
#22 – #18, Red #16 – #14, Blue #12 – #10, Yellow	- - - -	M8ND Y8ND	Die Set N10ET-9	Y10NCP	Die Set R10ET-3
4. T & B:					
#26 – #24, Yellow	- - - -	- - - -	- - - -	- - - -	- - - -
#22 – #18, Red #16 – #14, Blue #12 – #10, Yellow	- - - -	- - - -	- - - -	21728 & 21729	- - - -

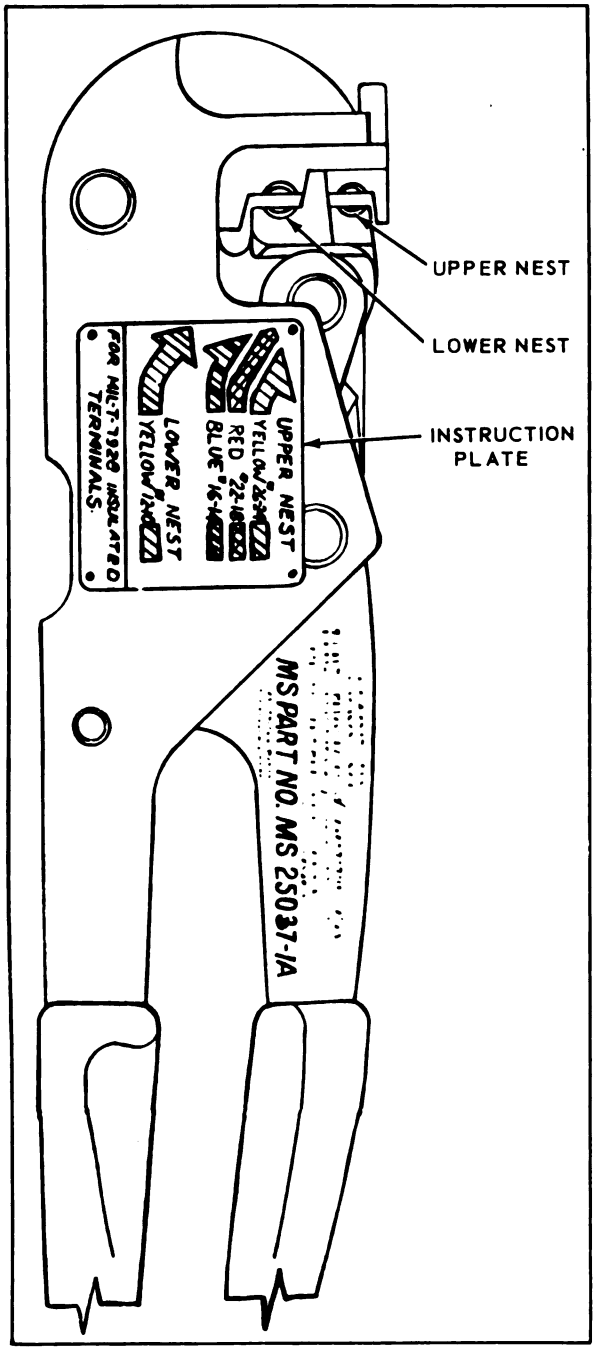


Figure 5–3. Tool MS25037 Hand Crimping – Pre-Insulated Copper Terminal Lugs

5–13. POWER TOOLS. Power crimping tools operate on air pressure. Power trigger must be depressed until crimp is complete. As indicated in table 5–2 power tools use specific inserts, called "Heads", "Dies" or "Die Sets" for each terminal lug size. Use correct insert for each terminal lug being crimped. See figure 5–4 and table 5–2 for details.

WARNING

ALWAYS disconnect power tool from its air pressure source, BEFORE installing or removing insert.

5–14. POWER TOOL INSPECTION AND ADJUSTMENT. AMP, Burndy and T & B power tools are checked by means of gages for proper adjustment. For good crimping results, this is done before each series of crimping operations. When the tool is adjustable, make proper correction; otherwise, return tool to manufacturer for repair. Check tools as follows:

a. AMP power tools are checked with the tool fully bottomed. The gap between the barrel crimping jaws and the gap between the insulation crimping jaws shall meet the requirements of table 5–3. Note that the "GO" gages shall be able to enter the jaws and the "No GO" gages shall not be able to enter. AMP power tools are not adjustable in the field.

b. Check Burndy tool Y10NCP, with die set R10ET-3 closed. The gap in the 22-18 (red) nest shall accept an .087 diameter rod and shall not accept a .105 diameter rod. Replace dies that are out of tolerance.

c. Check Burndy tool Y8ND, with die set #N10ET-9 fully closed. The gap in the 12-10 (yellow) nest shall accept a .140 diameter rod and shall not accept a .146 diameter rod. Replace dies that are out of tolerance.

d. T & B power tool No. 21728 is checked by closing the die over a No. 38 (.101) drill inserted in the smaller nest (for Red and Blue terminal lugs). The crimp adjustment screw is then tightened until the drill cannot be removed. Checking is required each time the insert is replaced.

5–15. CRIMPING PROCEDURE FOR MS25037 STANDARD HAND TOOL. Hand crimp pre-insulated copper terminal lugs in the No. 26-No. 10 wire size range with MS25037 standard hand tool as follows:

a. Strip wire insulation (lengths are given in table 5–4). Use one of recommended stripping procedures in section II, paragraphs 2–39 through 2–45.

b. Check tool for correct adjustment in accordance with 5–12. Tools out of adjustment must be returned to manufacturer for repairs.

c. Insert terminal lug, tongue first, into hand tool barrel crimping jaws, until terminal lug barrel butts flush against tool stop. See figure 5–5 for correct insertion method.

d. Squeeze tool handles slowly until tool jaws hold terminal lug barrel firmly in place, but without denting it.

e. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

f. Squeeze tool handles until ratchet releases.

g. Remove completed assembly and examine it for proper crimp, in accordance with 5–73.

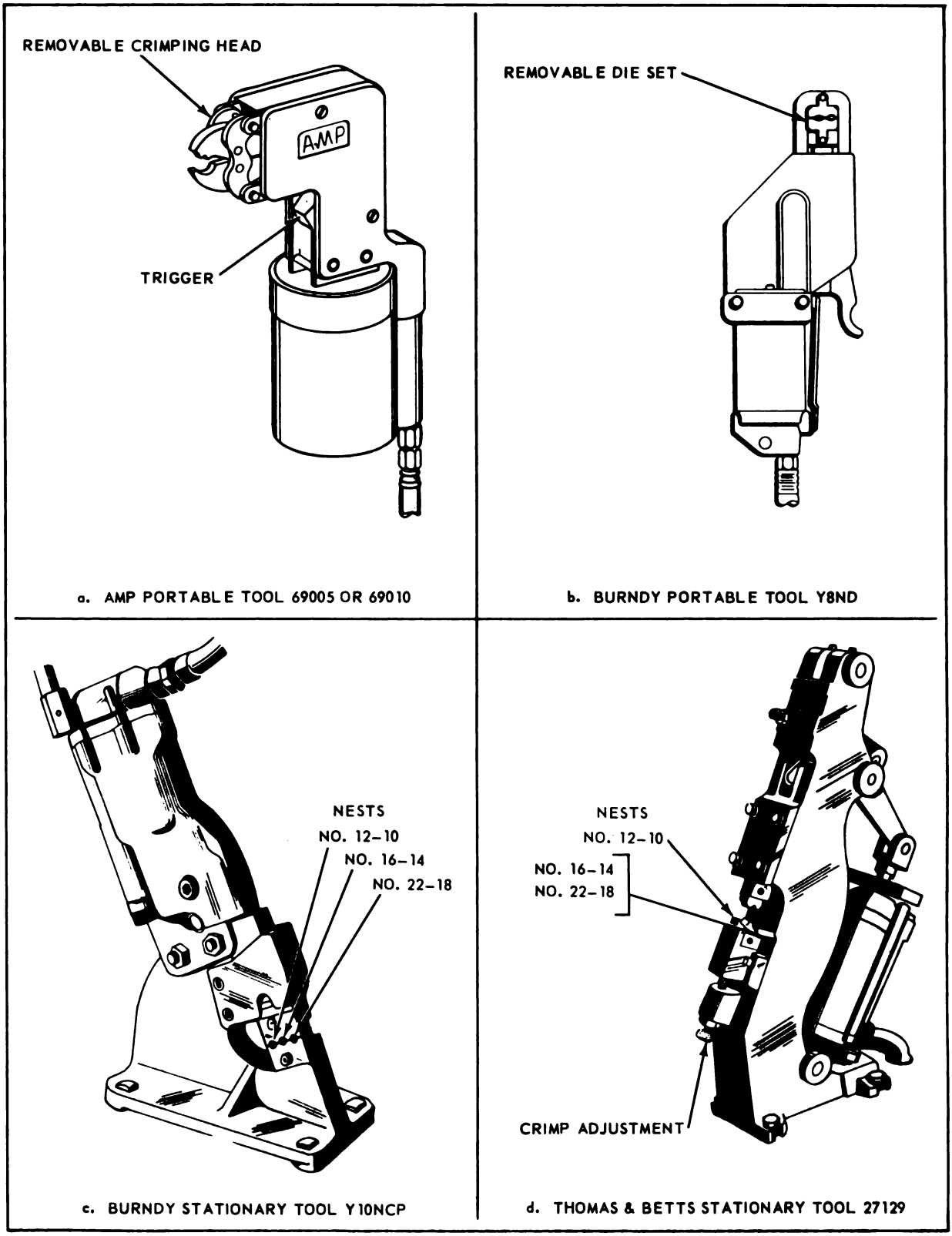


Figure 5–4. Tools – Power Crimping – Pre-Insulated Copper Terminal Lugs

TABLE 5–3

Gaging Dimensions for AMP Tools

Tool Wire Size Range	Tool	Gaging Dimension (Inches) For Barrel Crimping Jaws GO	For Barrel Crimping Jaws NO GO	*For Insulation Crimping Jaws GO	*For Insulation Crimping Jaws NO GO
22 - 16	47386	.098	.104	.030	.090
	59250	.109	.115		
16 - 14	47387	.108	.114	.040	.100
	59250	.115	.125		
12 - 10	59239	.139	.145	.064	.139

*When tools have adjustment pins (see 5–16) GO gaging is done with pins in Position No. 1; and NO GO gaging with pins in Position No. 3.

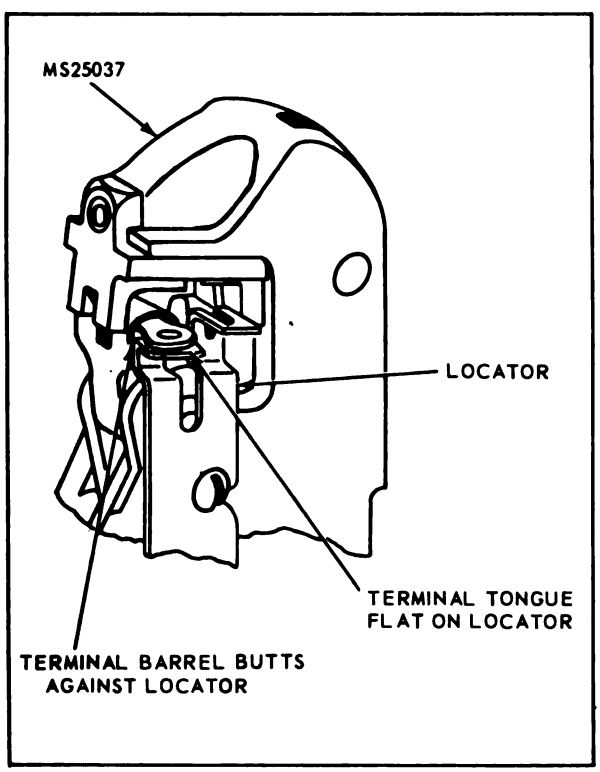


Figure 5–5. Inserting Terminal Lug into Hand Tool

TABLE 5–4

Wire Stripping Lengths for Small Copper Terminal Lugs

Wire Size	Stripping Length (in inches)
#26 & #24	5/32
#22 through #14	3/16
#12 & #10	9/32

5–16. CRIMPING PROCEDURE FOR AMP POWER TOOLS. Power-crimp AMP pre-insulated copper terminal lugs with AMP power tools as follows:

a. Select, from table 5–2, power tool and the correct insert for the terminal lug size being crimped.

b. Install insert in tool.

c. Check tool for proper adjustment in accordance with 5–14.

d. Check that removable stop plate is present on insert. When using tools No. 69005 and 69010 set insulation adjustment pins as follows:

1. Place both adjustment pins in the #3 position.

2. Place terminal in the tool crimping jaws and insert the unstripped wire into the terminal insulation grip only. Crimp the terminal.

3. Hold terminal firmly and bend the wire back and forth once. The terminal insulation grip should hold the wire.

4. If wire pulls out, set adjustment pins in the #2 position. Repeat test until insulation grip holds the wire firmly.

e. Strip wire insulation, using recommended stripping practices described in section II, paragraphs 2–39 through 2–46; stripping lengths are given in table 5–4.

f. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

g. Insert wire and terminal lug assembly in tool, until terminal lug barrel butts flush against tool stop. (When tool has no stop, center terminal lug barrel under indentor.)

h. Squeeze tool trigger, or actuate foot treadle.

i. Remove completed assembly and examine it for proper crimp in accordance with 5–73.

5–17. CRIMPING PROCEDURE FOR BURNDY POWER TOOLS. Power-crimp Burndy pre-insulated copper terminal lugs with Burndy power tools as follows:

a. Strip wire insulation, using recommended stripping practices described in section II, paragraphs 2–39 through 2–46. Stripping lengths are given in table 5–4.

b. Select from table 5–2 power tool that fits crimping conditions best, and the correct die set.

c. When using tool No. Y10NCP, check that removable stop-plate is present on die.

WARNING

ALWAYS disconnect power tool from its pressure source, BEFORE installing or removing dies.

d. Install insert in tool.

e. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

f. Insert wire and terminal lug assembly in tool, until terminal lug barrel butts flush against tool stop. (When tool has no stop, center terminal lug barrel under indentor.)

g. Squeeze tool trigger, or actuate foot treadle.

h. Remove completed assembly and examine it for proper crimp in accordance with 5–73.

5–18. CRIMPING PROCEDURE FOR T & B POWER TOOLS. Power-crimp T & B pre-insulated copper terminal lugs with T & B power tools, as follows:

a. Strip wire insulation, using recommended stripping practices described in section II, paragraphs 2–39 through 2–46; stripping lengths are given in table 5–4.

b. Select from table 5–2 the power tool that fits crimping condition best. T & B power tools listed include dies for wire sizes No. 22 - No. 10.

WARNING

ALWAYS disconnect power tool from its pressure source, BEFORE installing or removing dies.

c. Check power tools for proper adjustment in accordance with 5–14.

d. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

e. Insert wire and terminal lug assembly in tool, until terminal lug barrel butts flush against tool stop. (When tool has no stop, center terminal lug barrel under indentor.)

f. Squeeze tool trigger, or actuate foot treadle.

g. Remove completed assembly and examine it for proper crimp in accordance with 5–73.

5–19. TERMINATING LARGE COPPER WIRES (SIZES NO. 8 THROUGH NO. 4/0).

5–20. TERMINAL LUGS. Copper terminal lugs of all three styles, straight, angle and flag, are used to terminate copper wires of sizes No. 8 through No. 4/0. The style to be used depends on existing space conditions. As indicated in table 5–5, these terminal lugs are available uninsulated in all types, and preinsulated in the straight and angle types, though not necessarily in all wire sizes, or from all manufacturers. Straight pre-insulated terminal lugs conform to Military Specification MIL-T-7928 and Standard Drawing MS25036. As shown in figure 5–2, pre-insulated terminal lugs have the insulation extending beyond the barrel, so that it will cover a portion of the wire insulation. This makes the use of a separate insulating sleeve unnecessary. Straight uninsulated terminal lugs conform to Military Specification MIL-T-7928 and Standard Drawing MS-20659.

5–21. INSULATING SLEEVES. Uninsulated straight and right-angle type terminal lugs are insulated, after assembly to wire, by heat-shrinkable tubing (see section XI, paragraph 11–22) or by lengths of transparent tubing, called sleeves. These methods of insulation provide electrical and mechanical protection at the connection. When the size of sleeving used is such that it will fit tightly over the terminal lug, the sleeving need not be tied; otherwise, it is tied with lacing cord. (See figure 5–6). Tight fitting sleeves are expanded in methyl-ethyl-ketone solvent before installation. When the solvent evaporates, the sleeve will shrink tightly over the terminal lug.

WARNING

Methyl-ethyl-ketone is highly inflammable.

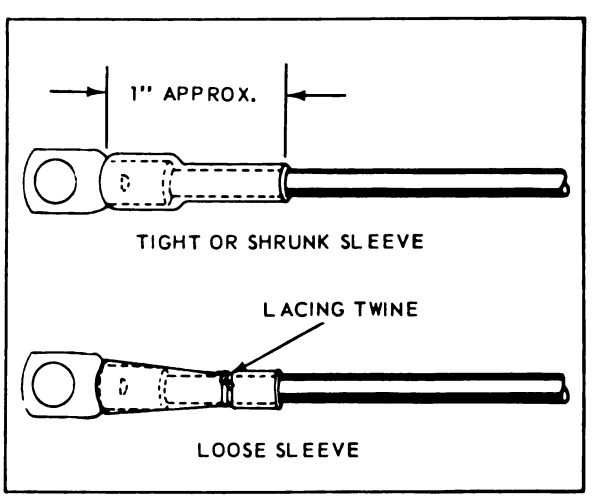


Figure 5–6. Insulating Sleeves

TABLE 5–5

Copper Terminal Lugs (Large) and Crimping Tools

Terminal Lugs	Crimping Tools and Size Range: Hand	Portable Power	Stationary Power
1. Straight, Pre-insulated			
MS25036	– – – –	MS25494, with MS25441-1 head, MS25441-3 hose & MS23002 dies (8-4/0)	MS25441, with MS23002 dies (8-4/0)
2. Straight, Uninsulated			
a. MS20659	AN3427(8-4/0)	– – – –	– – – –
b. Burndy	– – – –	Y29B (8-4/0)	Y29NSC (8-2/0)
c. T & B	– – – –	13586, with head 13642M (8-4/0)	13581, with head 13642M (8-4/0) 21073 (8-4/0)
3. Right-angle, Pre-insulated			
a. AMP	– – – –	69061 (8-2)*	69068 (8-2)* (8-4/0)**
b. Burndy	MY28-6(8-2/0)	Y29B (8-2/0)	Y29BUC (8-2/0)
4. Right-angle, Uninsulated			
a. Burndy	MY28	Y29B (8-2/0)	– – – –
b. T & B	WT-115 (8-4) WT-127 (2-4/0)	– – – –	21073 (8-4/0)
5. Flag, Uninsulated			
a. MS25189	AN3427		
b. Burndy	– – – –	Y29B (8-2/0)	Y29NSC (8-1/0)
c. T & B	– – – –	13586, with head 13642M (8-4/0)	13581, with head 13642M (8-4/0)

* Using Head No. 69051 with proper dies for each wire size
** Using Head No. 69066 with proper dies for each wire size

5–22. CRIMPING TOOLS. Hand, portable power and stationary power tools are available for crimping large copper terminal lugs. The crimping tools used on the pre-insulated terminal lugs crimp the barrel to the conductor, and simultaneously crimp the terminal lug insulation to the wire insulation. For best results Class I tools (those designated as either AN or MS tools) should be used. If Class II tools must be used, the crimping tools of each manufacturer should be used for the terminal lugs of the same manufacturer. The crimping tools most commonly used are listed in this manner in table 5–5. The numbers in parentheses after the tool numbers indicate the range of terminal lug sizes the tool can crimp; do not use any tools for larger terminal lug sizes than listed as this will result in a poor connection.

Note

Use power tools for large terminal lugs whenever possible.

5–23. HAND TOOLS. Hand crimping tools are available for MS20659, Burndy and T & B large copper uninsulated terminal lugs. These tools are illustrated in figure 5–7. The AN3427 and the Burndy hand tools, No. MY28 and MY28-6, each have a single nest and indentor; the nest is adjustable by means of a screw to the proper position for each terminal lug size. Note the shape of the indentor in figure 5–7a. It is used for crimping copper terminal lugs; do not confuse it with the indentor used for aluminum terminals as shown in figure 5–13. T & B tool No. WT 115 has a single in-

dentor and a nest wheel containing a specific nest for each terminal lug size; the nest is identified by means of letters, which correspong to terminal lug sizes, as listed on the tool itself. T & B tool No. WT 127 requires a different nest for each terminal lug size to be crimped; these nests are listed in table 5–6.

TABLE 5–6

Nests for T & B Hand Tool WT 127

Terminal Lug Size	For Use on Uninsulated Lugs Nest Number	Letter
2	21651	G
1	21652	H
1/0	21653	J
2/0	21654	K
3/0	21655	L
4/0	21656	M

5–24. HAND TOOL ADJUSTMENT. The Military Standard hand tool AN3427 has two positioning plates as shown in figure 5–7a. One plate is for installing one-piece terminal lugs and the other is for installing two piece and flag type terminal lugs. Adjust the position of each plate as follows:

a. Adjust one-piece terminal position plate to indicator guide line of No. 8 and No. 6 when an .090 diameter pin is just held by indentor and nest.

b. Adjust two-piece and flag type terminal position plate to indicator guide line of No. 8 and No. 6 when a .120 diameter pin is just held by indentor and nest.

5–25. The Burndy hand tool MY-28 is similar to Standard Tool AN 3427 and is adjusted the same way.

5–26. Thomas & Betts hand tool WT 115 is not adjustable and must be returned to the manufacturer if the following check reveals any defects.

a. Nest D should accept a 5/32 inch (.156) diameter pin when tool is fully closed.

b. Nest D should *not* accept a .166 diameter pin when tool is fully closed.

5–27. POWER TOOLS. Power crimping tools operate on either hydraulic power or air pressure. The Military Standard power tools MS25441 and MS25494, all AMP tools, and T & B tools No. 13586 and 13581 are hydraulically powered. All Burndy tools, and T & B tools other than those previously noted operate on air pressure. See figure 5–8 for illustrations of power tools.

5–28. Dies for the Class I Military Standard tools MS25441 and MS25494 are listed in table 5–7. Each terminal lug size requires a special die.

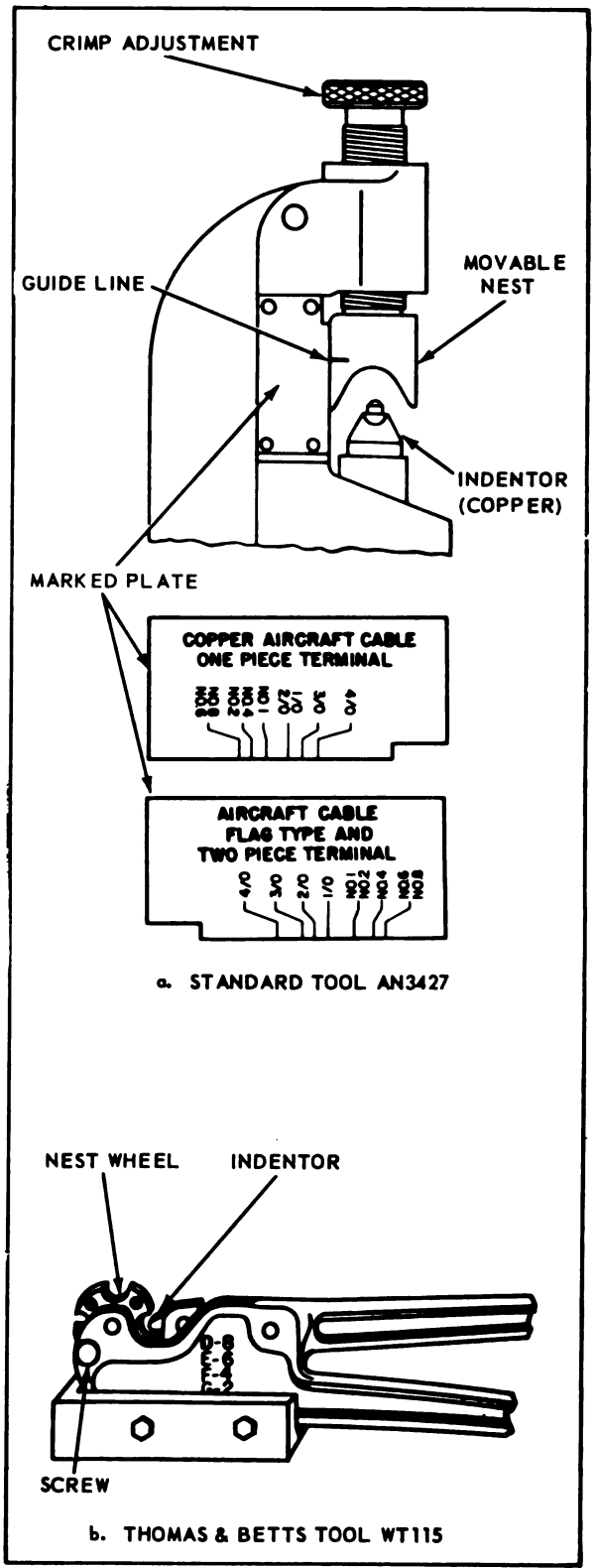


Figure 5–7. Tools – Hand Crimping Large Copper Terminal Lugs

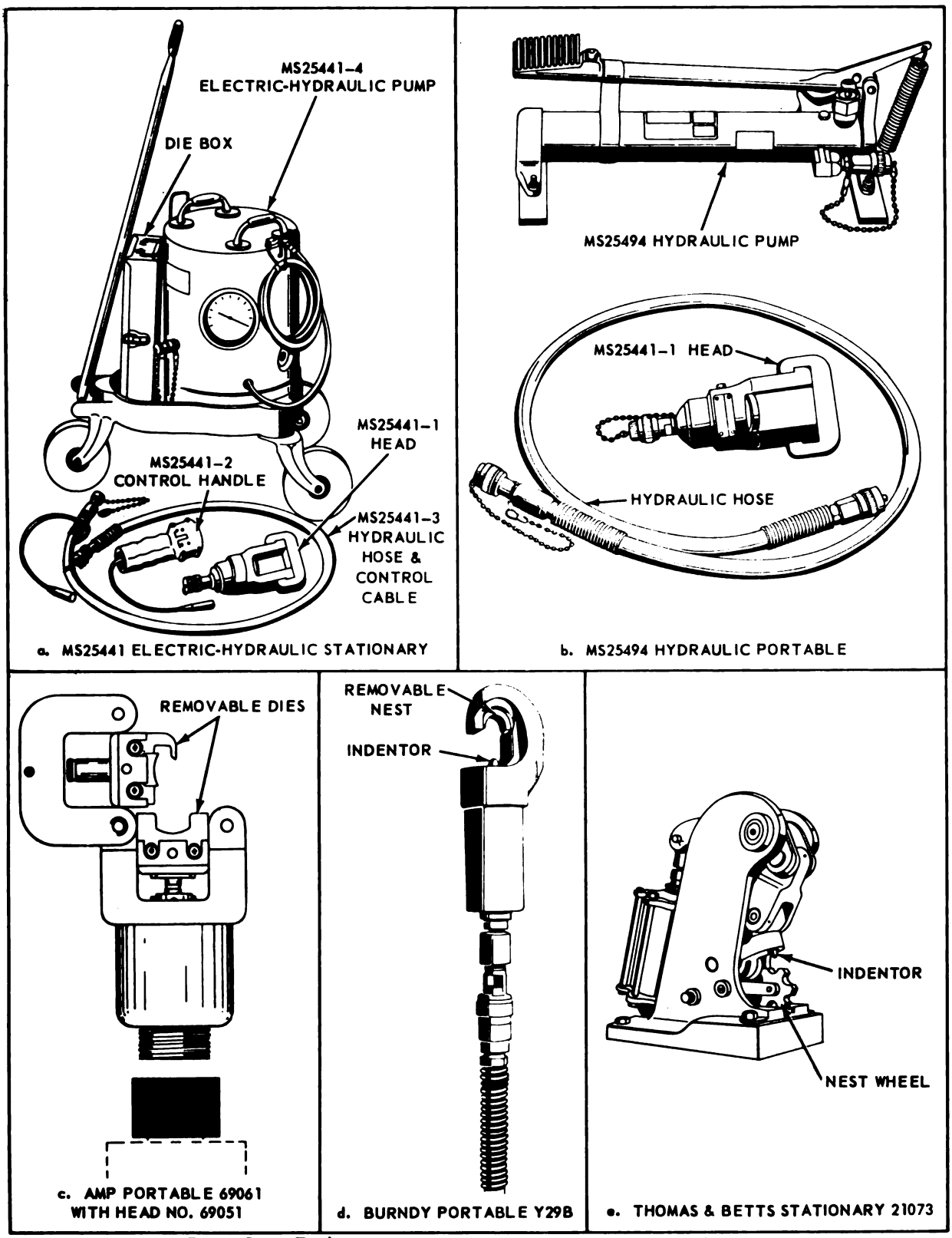


Figure 5-8. Tools – Power Crimping – Large Copper Terminal Lugs

TABLE 5–7

Dies and Gages for Military Standard Power Tools MS25441 and MS25494

Terminal Lug Size	MS Die Part Number (with Head MS25441–1)	MS Gage Part No.
8	MS23002 – 8	MS23003 – 8
6	MS23002 – 6	MS23003 – 6
4	MS23002 – 4	MS23003 – 4
2	MS23002 – 2	MS23003 – 2
1	MS23002 – 1	MS23003 – 1
1/0	MS23002 – 01	MS23003 – 01
2/0	MS23002 – 02	MS23003 – 02
3/0	MS23002 – 03	MS23003 – 03
4/0	MS23002 – 04	MS23003 – 04

5–29. AMP power tool dies are listed in table 5–8. Each terminal lug size requires a special die.

5–30. Each Burndy power tool, except tool No. Y29BUC, requires a different die set, (nest and indentor combination), for each size and type of terminal lug. These die sets are listed in table 5–9 for uninsulated terminal lugs, and in table 5–10 for pre-insulated terminal lugs. Burndy tool No. Y29BUC, uses two rack and indentor combinations, as listed in table 5–10.

5–31. T & B power tools Nos. 13586 and 13581 require separate indentor/nest combinations for each terminal size, as listed in table 5–11. T & B power tool No. 21073 includes dies.

5–32. POWER TOOLS ADJUSTMENT. The Military Standard, AMP, Burndy and T & B power tools can be checked for proper adjustment. For good crimping results, this must be done before each series of crimping operations. When tool is adjustable, proper correction must be made; otherwise, tool must be returned to manufacturer for repair. Check tools as follows:

a. Gage the dies of the Military Standard Tool in the closed position with the appropriate GO/No GO gages listed in table 5–7.

b. AMP tools are checked with tool fully bottomed. Gap between barrel crimping jaws of the dies shall meet the requirements of table 5–12. Note that "GO" gages shall be able to enter between jaws, and that "No GO" gages shall be unable to enter.

c. Burndy tools Y29B and Y29BUC when equipped with nests and indentors for pre-insulated terminal lugs (table 5–10) are checked to "G" dimensions listed in table 5–13. The "G" dimension is the clearance between nest and indentor when the tool is fully bottomed.

d. T & B power tool No. 210/3, is checked when tool is fully bottomed. An 11/32 inch (.344) drill shall enter between nest K and the indentor, and a 23/64 inch (.360) drill shall not enter. Dies for T & B tools 13586 and 13581 (similar to the Military Standard power tools listed in table 5–7) are gaged in the same way as the MS dies.

TABLE 5–8

Dies for AMP Power Tools 69061 and 69068

Terminal Lug Size	For Head No. 69061		For Head No. 69066	
	Vinyl Ins.	Nylon Ins.	Vinyl Ins.	Nylon Ins.
8	48752	47820	48858	
6	48753	47821	48859	
4	48754	47822	48860	
2	48755	47823	48861	
1/0			48756	47824
2/0			48757	47825
3/0			48758	47915
4/0			48759	47918

TABLE 5–9

Die Sets for Burndy Power Tools Y29B & Y29NSC

Terminal Lug Size	For Use on Straight & Right-Angle Type UNINSULATED Terminal Lugs		For Use on Flag Type UNINSULATED Terminal Lugs	
	Nest No.	Indentor No.	Nest No.	Indentor No.
8	DV8L	Y29PL	DV8B	Y29PBL
6	DV6L	Y29PL	DV6L	Y29PBL
4	DV4L	Y29PL	DV4BL	Y29PL
2	DV2L	Y29PL	DV2BL	Y29PBL
1	DV1L	Y29PL	DV1BL	Y29PL
1/0	DV25L	Y29PR	DV25BL	Y29PR
2/0	DV26L	Y29PR	*DV28L	*Y29PR
3/0	*DV27L	*Y29PR	– –	– –
4/0	*DV28L	*Y29PR	*DV28L	*Y29PR

*Use these nests & indentors on tool No. Y29B only, since tool No. Y29NSC is not powerful enough to be used on terminal lugs of this size.

TABLE 5–10

Die Sets for Burndy Power Tools Y29B & Y29BUC for PRE-INSULATED COPPER Terminal lugs

Terminal Lug Size	Burndy Die Set Number for Right Angle Terminal Lugs			
	For Tool No. Y29B		For Tool No. Y29BUC	
	Nest No.	Indentor No.	Rack No.	Indentor No.
8	DEV8L	Y29PLE–1	Y29BUR–7	Y29PU5
6	DEV6L	Y29PLE–1	Y29BUR–7	Y29PU5
4	DEV4L	Y29PLE–1	Y29BUR–7	Y29PU5
2	DEV2L	Y29PLE	Y29BUR–8	Y29PU1
1	DV26L	Y29PLE	Y29BUR–8	Y29PU1
1/0	DEV25L	Y29PLE	Y29BUR–8	Y29PU1
2/0	DEV26L	Y29PLE	Y29BUR–8	Y29PU1

TABLE 5–11

Die Sets for T & B Power Tools 13586 and 13581

Terminal Lug Size	Straight Type Terminals		Flag Type Terminals	
	Indentor	Nest	Indentor	Nest
8	13649M	13651	21731M	21733
6	13649M	13652	21731M	21734
4	13649M	13653	21731M	21735
2	13650M	13654	21732M	21736
1	13650M	13655	21732M	21737
1/0	13650M	13656	21732M	21738
2/0	13650M	13657	21732M	21739
3/0	13650M	13658	21732M	21740
4/0	13650M	13659	21732M	21741

TABLE 5–12

Gaging Dimensions for AMP Tools

AN Wire Size	Gaging Dimensions (in inches)	
	GO	NOGO
8	.200	.208
6	.236	.244
4	.268	.276
2	.318	.326
1/0	.399	.409
2/0	.445	.455
3/0	.497	.507
4/0	.559	.569

TABLE 5–13

"G" Dimensions for Burndy Power Tools

AN Wire Size	"G" Dimension (in inches)			
	Y29B		Y29BUC	
	MAX.	MIN.	MAX.	MIN.
8	.121	.094	.147	.132
6	.176	.149	.172	.157
4	.186	.161	.192	.177
2	.216	.184	.210	.190
1	.296	.266	.290	.270
1/0	.325	.295	.320	.300
2/0	–	–	.340	.320

5–33. CRIMPING PROCEDURE FOR AN3427 STANDARD HAND TOOL (Burndy Tool #MY-28). hand crimping of large copper terminal lugs is done as follows with Standard Tool AN3427 (Burndy #MY-28).

a. Strip wire insulation as described in section II, paragraphs 2–39 through 2–46. Wire stripping length for both uninsulated and pre-insulated *large* copper terminals shall be conductor barrel length plus 1/16 inch.

b. Set tool to proper crimping position by use of adjustment screw. (See figure 5–7a.)

c. Slide insulating sleeve (see 5–21) over wire insulation, well clear of crimping area. Do not use insulating sleeves with flag type terminal lugs.

d. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

e. Insert wire and terminal lug assembly in tool nest. Center barrel under tool indentor. Close handles all the way (until movable handle reaches fixed stop).

Note

Tongue of flag type terminal lug must rest flat against upper level of nest as shown in figure 5–9.

f. Remove completed assembly and examine it for proper crimp, in accordance with 5–73 and 5–74.

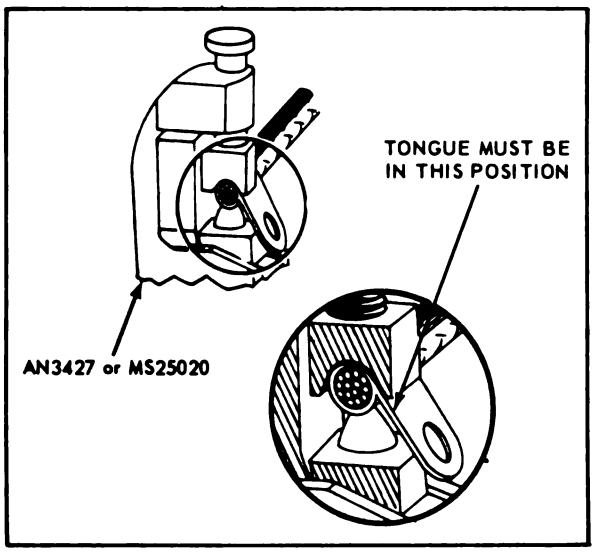


Figure 5–9. Positioning Flag Type Terminal Lugs

g. Slide insulating sleeve over terminal lug barrel and secure it in accordance with 5–21 and figure 5–6.

5–34. CRIMPING PROCEDURE FOR T & B HAND TOOLS. Hand-crimp large T & B copper terminal lugs as follows:

a. Strip off wire insulation, using recommended practices described in section II, paragraphs 2–39 through 2–46. See 5–33a for stripping length.

b. Select from table 5–5 the proper hand tool for terminal lug type and size being crimped.

c. Check tool for correct adjustment in accordance with 5–26.

d. Prepare tool for cimping as follows:

1. Tool No. WT 115: loosen thumbscrew, turn nest-wheel until proper nest for termiaal lug size being crimped is opposite indentor and retighten thumbscrew.

2. Tool No. WT 127: insert proper nest for terminal lug size being crimped, in accordance with table 5–6.

e. Slide insulating sleeve if required (see 5–21) over wire insulation well clear of crimping area. Do not use insulating sleeve with pre-insulated terminal lugs, or with flag type terminal lugs.

f. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

g. Insert wire and terminal lug assembly in tool nest. Center barrel under tool indentor.

h. Close tool handles all the way (until movable handle reaches fixed stop).

i. Remove completed assembly and examine it for proper crimp, in accordance with 5–73.

j. Slide insulating sleeve over terminal lug barrel and secure it, in accordance with 5–21 and figure 5–6.

5–35. CRIMPING PROCEDURE FOR MILITARY STANDARD POWER TOOLS. Power-crimp large Military Standard copper terminals MS25036, as follows:

a. Select proper die for wire size from table 5–7, and install die in tool.

b. Strip wire insulation, using recommended practices described in section II, paragraphs 2–39 through 2–46; stripping lengths are given in 5–33a.

c. Insert stripped wire into terminal barrel until wire insulation butts flush against end of barrel.

d. Insert wire and terminal lug assembly into die.

e. Actuate the power tool (press button on handle for electrically operated tool; actuate handle for manual hydraulicly operated tool).

f. Remove the crimped assembly, and examine it for proper crimp, in accordance with 5–73.

5–36. CRIMPING PROCEDURE FOR AMP POWER TOOLS. Power-crimp large AMP copper pre-insulated terminal lugs as follows:

a. Strip wire insulation, using recommended stripping practices in section II, paragraphs 2–39 through 2–46; stripping lengths are given in 5–33a.

b. Select the proper insert for the terminal lug size being crimped from table 5–8.

WARNING

ALWAYS disconnect a power tool from its pressure source, whether air or hydraulic, BEFORE installing or removing its insert.

c. Install insert in tool.

d. Check tool for proper adjustment in accordance with 5–32.

e. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

f. Insert wire and terminal lug assembly in tool nest, so that terminal lug barrel butts flush against tool stop.

g. Squeeze tool trigger or actuate foot treadle.

h. Remove completed assembly and examine it for proper crimp in accordance with 5–73.

5–37. CRIMPING PROCEDURE FOR BURNDY POWER TOOLS. Power-crimp large Burndy copper terminal lugs as follows:

a. Strip wire insulation, using recommended stripping practices described in section II, paragraphs 2–39 through 2–46; stripping lengths are given in 5–33a.

b. Select from table 5-5 a power tool for terminal lug style and size being crimped. Pick tool that fits crimping conditions best.

c. Select proper insert for tool from tables 5-9 or 5-10, depending on terminal lug style.

WARNING

1. ALWAYS disconnect power tool from its pressure source, BEFORE installing or removing its insert.

2. When using tool No. Y29BUC, ALWAYS remove nest rack BEFORE installing or removing indentor.

d. Install insert in tool.

e. Slide insulating sleeve over wires to be connected to uninsulated terminal lugs (see 5-21). Do not use insulating sleeves for flag type terminals.

f. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

g. Insert wire and terminal lug assembly in tool nest. Center barrel under indentor.

h. Squeeze tool trigger or actuate foot treadle.

i. Remove completed assembly and examine it for proper crimp in accordance with 5-73 and 5-74.

j. Where used, slide insulating sleeve over terminal lug barrel and secure, in accordance with 5-21 and figure 5-6.

5-38. CRIMPING PROCEDURE FOR T & B POWER TOOLS. Power-crimp large T & B copper terminal lugs as follows:

a. Strip wire insulation, using recommended stripping practices described in section II, paragraphs 2-39 through 2-46; stripping lengths are given in 5-33.

b. Select from table 5-5 a power tool for terminal lug style and size being crimped. Pick tool that fits crimping conditions best.

c. Set tool No. 21073 by rotating nest wheel to index proper nest opposite indentor. Install correct nest and indentors in other tools, from table 5-11.

d. Slide insulating sleeve over wires to be connected to uninsulated terminal lugs (see 5-21). Do not use insulating sleeves for flag type terminals.

e. Insert stripped wire into terminal lug barrel until wire insulation butts flush against end of barrel.

f. Insert wire and terminal lug assembly in tool nest. Center barrel under indentor.

g. Squeeze tool trigger or actuate foot treadle.

h. Remove completed assembly and examine it for proper crimp in accordance with 5-73.

i. Where used, slide insulating sleeve over terminal lug barrel and secure, in accordance with 5-21 and figure 5-6.

5-39. HIGH TEMPERATURE TERMINAL LUGS.

5-40. In areas where the temperature is expected to exceed 300°F, special terminal lugs are used. These are copper, either nickel or silver plated, and insulated with a high temperature material such as TFE or Kel-F. These terminal lugs can be used where the continuous operating temperature does not exceed 500°F. Terminal lugs made by Burndy and Thomas & Betts are pre-insulated; those made by AMP are provided with a TFE sleeve having a metal crimping ring which is crimped into the terminal lug after the wires have been inserted.

5-41. CRIMPING TOOLS. Hand, portable power and stationary power tools are used to install high temperature terminal lugs on electrical wire. These tools are listed in table 5-14.

5-42. HAND TOOLS. Hand tools are of the self-locking ratchet type. AMP hand tools are used on one terminal size only; the tool handle is color coded to match the insulation color of the terminal. Burndy and T & B tools are furnished with dies for the wire ranges; the opening for each wire size range is maked.

5-43. POWER TOOLS. Power crimping tools operate on air pressure. AMP tools require an insert or die for each wire size range; Burndy tools require a separate die set for each wire size range. (See table 5-14).

5-44. CRIMPING PROCEDURE FOR AMP HAND TOOLS. Hand crimp AMP high temperature terminal lugs as follows: (See figure 5-10).

a. Strip wire length of terminal barrel, plus 1/32 inch.

b. Open tool jaws by squeezing tool handles until ratchet releases.

c. Place terminal in crimping nest and center the terminal barrel in the nest.

d. Place insulating sleeve on the wire, well back from the crimping area.

e. Insert stripped wire into terminal, and crimp by closing tool handles until ratchet releases. Remove the crimped terminal and install the insulating sleeve over the barrel as shown.

f. Center the sleeve ring in the crimping nest of tool; close handles only far enough to hold the sleeve firmly in place. Wire may be moved to position terminal sleeve, so that it extends 1/32 inch beyond end of terminal barrel.

g. Complete crimp by squeezing handles until ratchet releases.

TABLE 5-14

High Temperature Terminal Lugs and Crimping Tools

Wire Size Range	Color Code	Hand Tool	Crimping Tools	
			Portable Power	Stationary Power
1. AMP				
#22 – #20	Silver	46467	69100, with die 46464	
#18 – #16	Red	46468	69100, with die 46465	
#14	Blue	46469	69100, with die 46466	
#12 – #10	Yellow	46470		
2. Burndy				
#22 – #16	Red	MR 8-36T	M8ND, Y8ND, with die set N10JT-9	Y10NCP, with die set R10HJT-1T
#16 – #14	Blue	MR8-36T	M8ND, Y8ND, with die set N10JT-9	Y10NCP, with die set R10HJT-1T
#12 – #10	Yellow	MR8-36T	M8ND, Y8ND, with die set N10JT-9	Y10NCP, with die set R10HJT-1T
#8	- - - -	MY4-25	Y29NC, with die set DJV8C -HT	
3. T & B				
#22 – #20	Green Stripe	WT-187		
#20– #18	Red Stripe	WT-188		
#16 – #14	Yellow Stripe	WT-188		

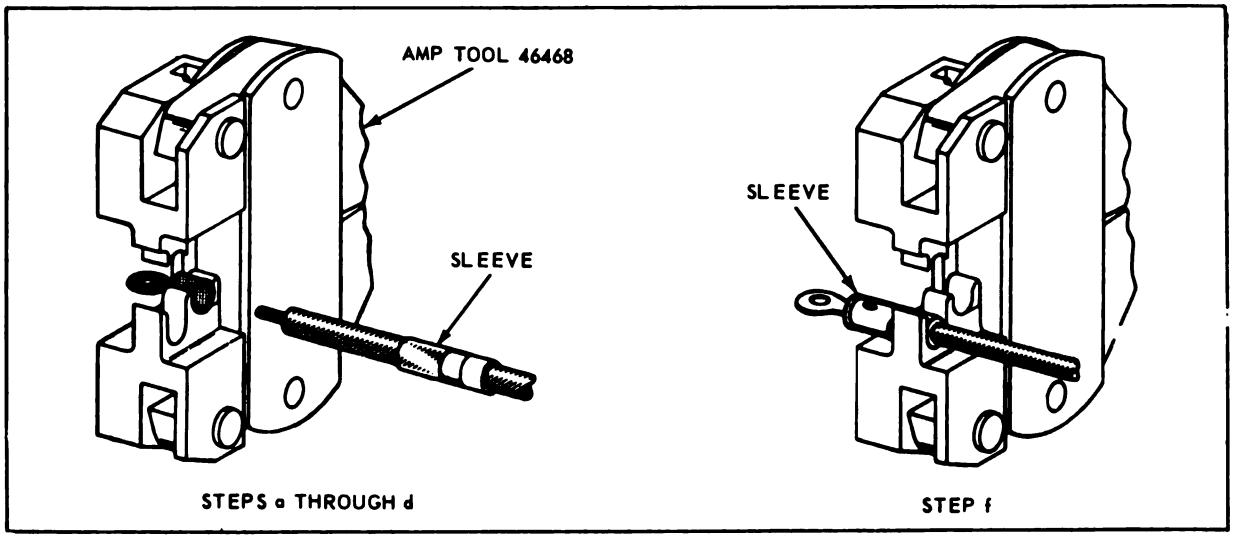


Figure 5-10. Crimping High Temperature Terminal Lugs

5-45. CRIMPING PROCEDURE FOR BURNDY HAND TOOLS. The procedure for crimping Burndy high temperature terminal lugs is as follows:

a. Strip wire to length of terminal barrel, plus 1/32 inch.

b. Insert stripped wire into terminal.

c. Open jaws of tool by squeezing handles together as far as they will go, and then releasing them.

d. Place terminal and wire assembly into correct groove of tool, so that terminal barrel rests against stop.

e. Crimp by closing handles all the way.

5-46. CRIMPING PROCEDURE FOR T & B HAND TOOLS. The procedure for crimping T & B high temperature terminal lugs is similar to the procedure described in 5-15 for small copper terminal lugs.

5-47. CRIMPING PROCEDURE FOR AMP POWER TOOLS. Power-crimp AMP high temperature terminal lugs as follows:

a. Strip wire to length of terminal barrel, plus 1/32 inch.

b. Open die and insert terminal barrel so it centers in stationary die nest. Brazed seam on terminal barrel should face upward.

c. Close jaws just enough to hold terminal in place. Make sure terminal barrel remains centered in die.

d. Place insulating sleeve on wire back from stripped end.

e. Insert stripped wire in terminal barrel, and crimp, holding wire firmly in place.

f. Remove assembly, and pull sleeve into place over terminal barrel.

g. Place assembly into die so that sleeve ring is centered in nest of stationary die.

h. Close jaws just enough to hold assembly, and make sure sleeve ring remains centered. Complete crimp and remove assembly.

5-48. CRIMPING PROCEDURE FOR BURNDY POWER TOOLS. The procedure for crimping Burndy high temperature terminal lugs is similar to the procedure for crimping small copper terminals to wire. See 5-17.

5-49. TERMINATING ALUMINUM WIRE.

5-50. GENERAL. Aluminum wire is used in aircraft because of its weight advantage over copper. Aluminum, however, has the disadvantage of being softer than copper. Further, bending aluminum wire will cause "work hardening" of the metal which makes it more brittle. This will result in failure or breakage of strands much sooner than in copper wire. Aluminum also forms a high resistance oxide film immediately upon exposure to air. To compensate for these disadvantages it is important to follow carefully the recommended installation procedures.

WARNING

Do not use any aluminum wire which has nicked or broken strands. Damaged strands will fail in service.

5-51. ALUMINUM TERMINAL LUGS. Aluminum terminal lugs are used only to terminate aluminum wires. See figure 5-1 for typical connections. Aluminum terminal lugs are available in three types, straight, 90 degree upright, and angle (left or right). The barrels of aluminum terminal lugs are filled with a petroleum-base abrasive compound. This compound, by a grinding process during the crimping operation removes the oxide film from the aluminum. The compound also prevents oxide from re-forming in the completed connection. All aluminum terminals have an inspection hole to allow checking the depth of wire insertion (see figure 5-1). This inspection hole is sealed with a removable plastic plug, which also serves to retain the oxide-inhibiting compound. Each aluminum terminal lug is marked with the letters "AL" indicating it is for use with aluminum wire, and also with the wire size it will accommodate.

CAUTION

Do not remove the inspection plug until the crimp has been completed, and the wire insertion is to be inspected. Replace plug after inspection.

5-52. INSULATING SLEEVES. Aluminum terminal lugs are not preinsulated, therefore it is necessary to insulate them after assembly, by lengths of transparent flexible tubing, called sleeves. The sleeve provides mechanical and electrical protection at the connection. (See figure 5-6).

5-53. CRIMPING TOOLS. Power tools, either stationary or portable, are recommended to install aluminum terminal lugs. Use the Military Stantard Tools MS25441 and MS25494 to install MS aluminum terminal lugs. Install other aluminum terminal lugs with the tools listed in table 5-15. The numbers in parentheses listed after the tool numbers indicate the range of wire sizes that can be safely crimped with that tool.

CAUTION

Do not use any crimping tool beyond its rated capacity.

5-54. HAND TOOLS. The Military Standard hand tool MS25020 shown in figure 5-13 is obsolete for use on aluminum terminal lugs. This tool was formerly used to crimp MS25021 and MS25022 aluminum terminal lugs, which have now been superseded by the Military Standard terminals listed in table 5-15.

CAUTION

Do not use the MS25020 tool on Military Standard Terminals MS25435, 25436, 25437 or 25438. Use this tool only for such obsolete aluminum MS terminals as may be still stocked.

5-55. POWER TOOLS. See figure 5-8. MS 25441 is a complete electric-hydraulic tool, consisting of an electric pump, hydraulic head, hydraulic hose, and control handle. A foot operated pump MS25494 can be used to supply hydraulic pressure for MS25441-1 head. All power tools require a specific insert die for each terminal lug size. These dies are listed in table 5-16, and 5-17. Burndy power tools may be used only to install the obsolete Military Standard terminal lugs MS25021 and 25022.

CAUTION

Do not use Burndy power tools on Military Standard terminal lugs MS25435, 25436, 25437 or 25438.

5-56. POWER TOOL INSPECTION. Dies for the Military Standard tools MS25441 and MS25494 are checked with MS25472 gages. Check the dies in the closed position with the appropriate Go/No Go gages listed in table 5-18.

5-57. CRIMPING PROCEDURE FOR MILITARY STANDARD POWER TOOLS. Power-crimp Military Standard (except MS25021 and 25022) aluminum terminal lugs as follows:

a. Select power tool from table 5-15. Use tool that fits crimping conditions best.

b. Select proper die for wire size from table 5-16. Die is stamped with the wire size on both upper and lower faces and with the letters AL. Install die in tool head.

WARNING

ALWAYS disconnect power tool from its pressure source BEFORE installing or removing die.

TABLE 5-15

ALUMINUM Terminal Lugs and Crimping Tools

Aluminum Terminal Lugs	Hand Tool	Power Crimping Tools and Wire Size Range	
		Portable Power	Stationary Power
1. MS25435, 25436, 25437 and 25438	- - - -	MS25494, with Head MS25441-1 (8-4/0)	MS25441 (8-4/0)
2. *Burndy:			
*Straight			
*MS25021	*MS25020	Y29B (8-4/0)	Y29NSC (8-4/0)
*Flag			
*MS25022	*MS25020	Y29NC (8-1/0)	- - - - - - - -

*Items marked * are obsolete

TABLE 5-16

Dies used on Military Standard Power Tool for Crimping ALUMINUM Terminal Lugs

Terminal Size	Dies for MS Tools Head #MS25441-1
8	MS25442-8A
6	MS25442-6A
4	MS25442-4A
2	MS25442-2A
1	MS25442-1A
1/0	MS25442-01A
2/0	MS25442-02A
3/0	MS25442-03A
4/0	MS25442-04A

TABLE 5–17

Die Sets for Burndy Power Tools Y29B, Y29NC & Y29NSC, for Crimping MS25021 and 25022 ALUMINUM Terminal Lugs ONLY

Lug Size	Die Sets For Straight Type Terminal Lugs		For Flag Type Terminal Lugs	
	Nest	Indentor	Nest	Indentor
8	DV8L–1	Y29PL	DV8B	Y29PBL
6	DV6L–1	Y29PL	DV6L	Y29PBL
4	DV4L	Y29PLA	DV4BL	Y29PBL
2	DV2L	Y29PLA	DV2BL	Y29PLA
1	DV25L	Y29PA	DV1BL	Y29PA
1/0	DV26L	Y29PA	DV25BL	Y29PA
2/0	*DV27L	*Y29PA	*DV28L	*Y29PA
3/0	*DV28L	*Y29PA	*DV28L	*Y29PA
4/0	*DV28L	*Y29PA	*DV28L	*Y29PA

*For use on tool No. Y29B only, since tools Y29NC & Y29NSC are not powerful enough for these terminal lug sizes.

TABLE 5–18

Gages for MS25442 Crimping Dies

Die Dash Number	Gage MS25472 Dash Number
–8A	–1
–6A	–2
–4A	–3
–2A	–4
–1A	–5
–01A	–6
–02A	–7
–03A	–8
–04A	–9

c. Strip wire insulation carefully, using recommended stripping practices for aluminum wire described in section II, paragraphs 2–40 through 2–46; stripping lengths are listed in table 5–19.

d. Install insulating sleeve over wire insulation, well back from crimping area.

e. Inspect to see that inner barrel is well coated with compound.

f. Insert wire into terminal barrel.

CAUTION

Do not remove the inspection plug as this keeps the compound in the barrel. When the wire is inserted to the full depth of the barrel the compound is forced between and around the conductor strands.

g. Wipe off any excess compound squeezed out of terminal lug barrel with a clean soft cloth.

h. Insert assembly into the die correctly positioned as shown in figure 5–11.

i. Actuate the power tool. When using MS25441, press the lower button on the control handle. Do not release the button until the dies open automatically. When using MS25494, close the release knob and actuate the pump handle. When the dies have been closed to a pre-determined pressure the terminal can be released by opening the release valve.

Note

Wire sizes No. 8 to No. 2/0 require only one crimp. Wire sizes No. 3/0 and No. 4/0 require two crimps. Locate the second crimp centrally on the portion of the barrel remaining after the first crimp. See figure 5–12.

j. Check visually to see that the correct wire size is imprinted on the barrel.

k. Remove the inspection plug and check visually or with the aid of a probe to see that wire is fully inserted. Replace the plug after inspection.

l. Slide insulating sleeve over the terminal lug barrel and secure in accordance with 5–21 and figure 5–6.

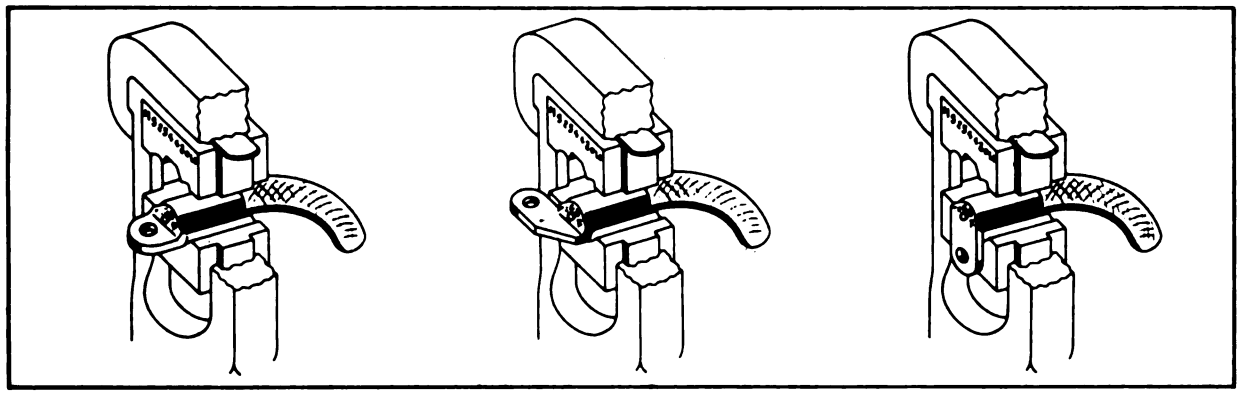


Figure 5–11. Positioning Aluminum Terminal Lugs in Die Nests

TABLE 5–19

Stripping Lengths for ALUMINUM Wire

Wire Size	Stripping Length (in inches) MS25435, 25436, 25437,& 25438	*MS25021	*MS25022
8	11/16	7/16	1/2
6	13/16	1/2	1/2
4	27/32	5/8	9/16
2	1– 1/32	5/8	**5/8
1	1– 1/32	3/4	**3/4
1/0	1– 1/32	13/16	**13/16
2/0	1– 7/32	15/16	15/16
3/0	1– 9/32	15/16	15/16
4/0	1– 7/16	1	1

* Items marked * are obsolete.
**Except for 1/2 inch stud size terminal lugs, where stripping lengths are 13/16, 7/8 and 7/8 for wire sizes 2, 1 and 1/0 respectively.

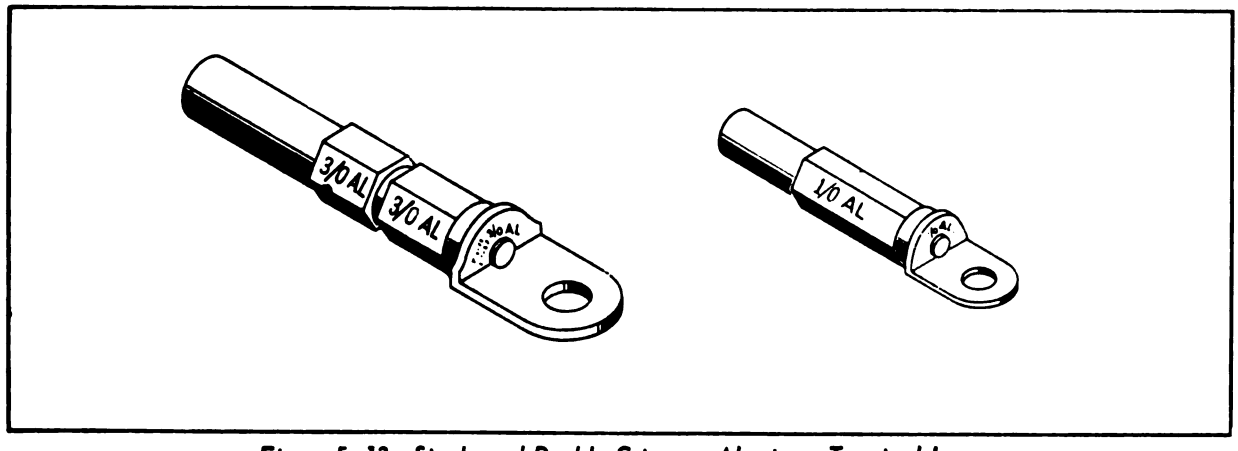


Figure 5–12. Single and Double Crimp on Aluminum Terminal Lugs

5–58. CRIMPING PROCEDURE FOR MILITARY STANDARD MS25020 HAND TOOL. This tool shall be used *only* to crimp obsolete aluminum terminal lugs MS25021 and 25022. The procedure is as follows:

a. Set tool to proper crimping position for terminal lug size being crimped. This is done by moving nest by means of adjustment screw until guide line on nest is centered over line on marked plate corresponding to terminal lug size being crimped. See figure 5–13.

b. Carefully strip wire insulation, using recommended stripping practices for aluminum wire described in section II, paragraphs 2–40 through 2–46; stripping lengths are listed in table 5–19.

c. When crimping straight or right-angle type terminal lugs, slip insulating sleeve over wire insulation, well clear of crimping area.

d. Remove protective cover from terminal lug barrel. See figure 5–14.

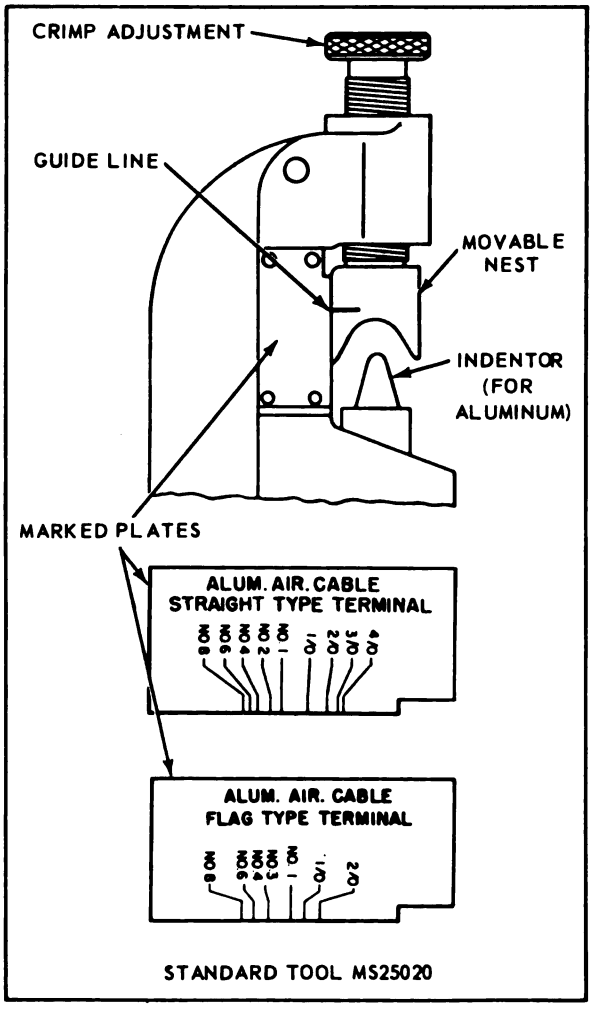


Figure 5–13. Tool–Hand Crimping–Aluminum Terminal Lugs

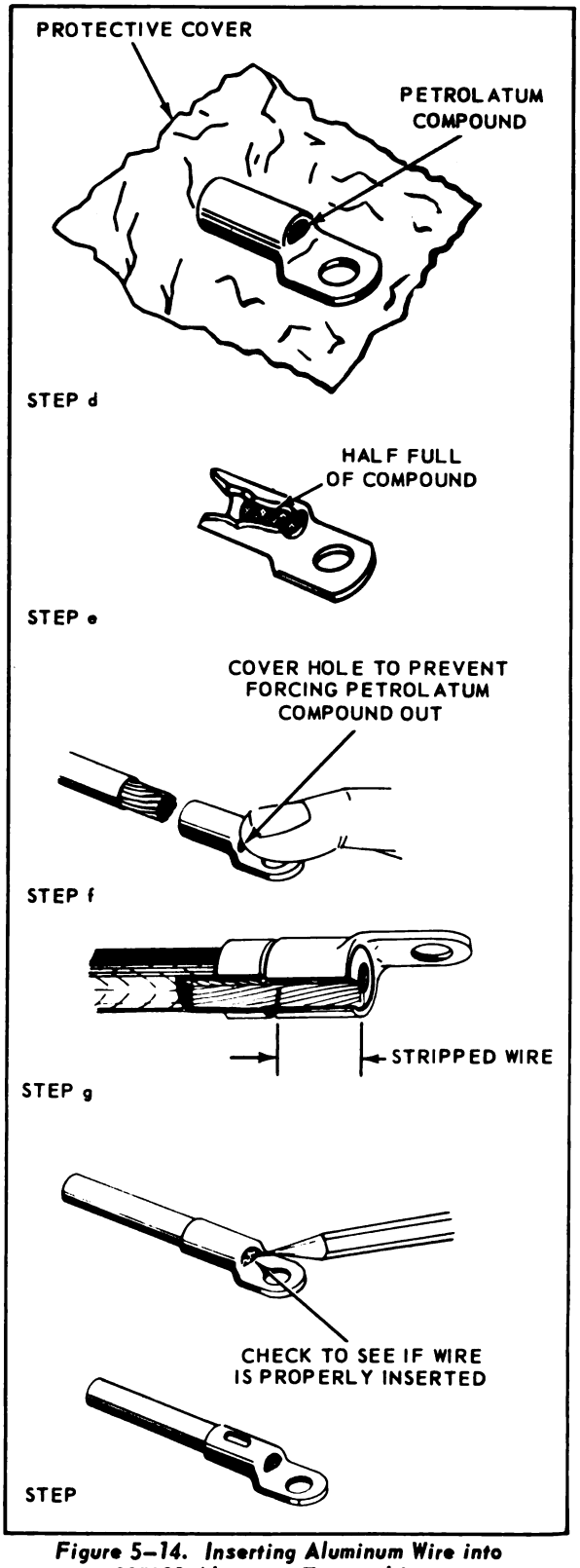


Figure 5–14. Inserting Aluminum Wire into MS25021 Aluminum Terminal Lugs

e. Check that terminal lug barrel is at least half-full of petrolatum-zinc dust compound. If not, add additional compound.

f. Hold terminal lug in one hand, with finger fully blocking inspection hole to prevent loss of compound, and pick up wire in other hand.

g. Insert stripped wire into terminal lug barrel. Do not twist wire during insertion.

h. Hold wire and terminal lug assembly firmly together and wipe off any excess compound squeezed out of terminal lug barrel with a soft dry cloth.

i. Check inspection hole, visually or with a wire probed, and make sure that wire end reaches all the way into terminal lug barrel.

j. Insert wire and terminal lug assembly into tool, so that terminal lug barrel is centered over tool indentor. Tongue of flag type terminal lug must rest flat against side of tool nest. See figure 5–9.

k. Close tool handles all the way or until movable handle meets stop.

l. Remove completed assembly from tool.

m. Wipe off excess compound squeezed out of terminal lug barrel with a soft dry cloth.

n. Examine assembly for proper crimp in accordance with 5–73 and 5–74.

o. Slide insulating sleeve over terminal lug barrel and secure it in accordance with 5–21 and figure 5–6.

5–59. CRIMPING PROCEDURE FOR BURNDY POWER TOOLS. The Burndy power tools listed in table 5–15 are used *only* to crimp obsolete aluminum terminal lugs MS25021 and MS25022. The following procedure is used:

a. Select the correct insert from table 5–17.

b. Install insert in tool.

WARNING

ALWAYS disconnect power tool from its pressure source BEFORE installing or removing insert.

c. Carefully strip wire insulation to length given in table 5–19 using recommended stripping practices for aluminum wire described in section II, paragraphs 2–40 through 2–46.

d. When crimping straight type terminal lugs, slip insulating sleeve over wire insulation, well clear of crimping area.

e. Remove protective cover from terminal lug barrel. (See figure 5–14).

f. Check that terminal lug barrel is at least half-full of petrolatum-zinc dust compound. If not, add additional compound.

g. Hold finger over inspection hole to prevent loss of compound. Insert stripped wire into terminal lug barrel. Do not twist wire.

h. Hold wire and terminal lug firmly together and wipe off any excess compound squeezed out of terminal lug barrel with a soft dry cloth.

i. Check inspection hole, visually or with a wire probe, and make sure that wire end reaches all the way into terminal lug barrel.

j. Insert wire and terminal lug assembly into tool, so that terminal lug barrel is centered over tool indentor.

k. Actuate power tool.

l. Remove completed assembly from tool.

m. Examine assembly for proper crimp in accordance with 5–73 and 5–74.

n. Slide insulating sleeve (if used) over terminal lug assembly and secure it in accordance with 5–21 and figure 5–6.

5–60. SPLICING SMALL COPPER WIRES (SIZES NO. 26 THROUGH NO. 10).

5–61. PRE-INSULATED SPLICES. Pre-insulated permanent copper splices are used to join small copper wires of AN wire sizes No. 26 through No. 10. Typical splices are shown in figure 5–1. Note that splice pre-insulation extends over the wire insulation. Each splice size can be used for more than one wire size. Splices are color coded in the same manner as pre-insulated small copper terminal lugs; refer to 5–9 and table 5–1 for details. Splices are also used when authorized to reduce wire sizes, as shown in figure 5–15, for special applications (see figure 5–16), and for multiple wire applications.

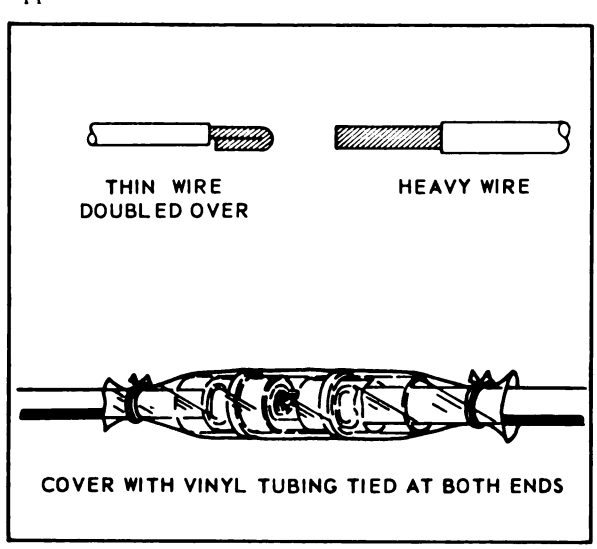


Figure 5–15. Reducing Wire Size with Permanent Splice

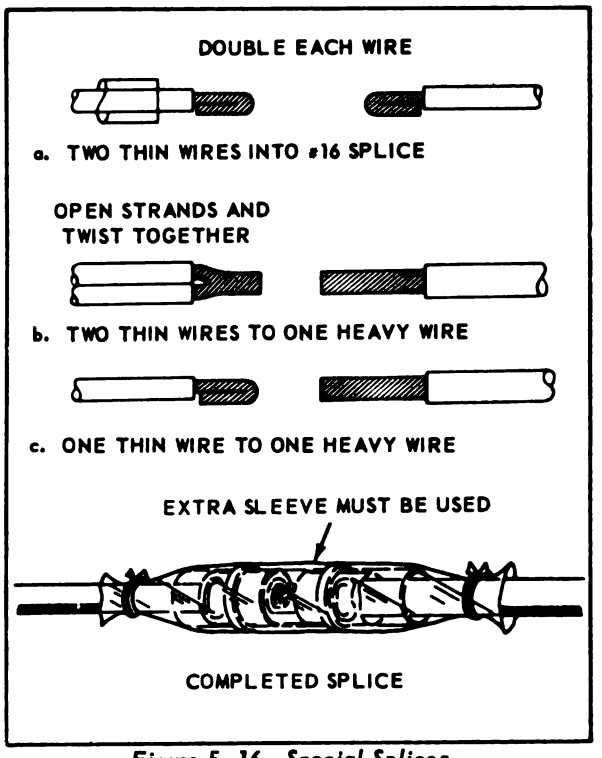


Figure 5-16. Special Splices

5-62. CRIMPING TOOLS. The Military Standard tool MS25037 is used to crimp the small Military Standard copper splices MS25181. See 5-11 and 5-12 for tool description and inspection.

5-63. CRIMPING PROCEDURE FOR MS25037 STANDARD HAND TOOL. Crimp small pre-insulated copper splices in the No. 26 No. 10 wire size range as follows:

a. Swing the stop plate used for installing small insulated terminal lugs out of the way. (See figure 5-17)

b. Strip wire to length given in table 5-20, following the procedures described in section II, paragraphs 2-40 through 2-46.

CAUTION
Inserting the splice in the wrong part of the crimper will result in a splice that will pull out.

c. Put the splice in the crimping tool with the center of the splice closest to the flat die. In this way the bare stripped wire will receive the heavier crimp. The part of the wire which is insulated will then be in the conical side which receives a lighter crimp.

d. Insert wire into the "wire in" side of splice so that the stripped conductor butts against the stop in the center of the splice. This can be seen through the splice inspection window.

e. Crimp by closing tool handles; tool will not open until full crimping pressure has been applied.

f. After crimping, check that wire end is still visible through inspection window.

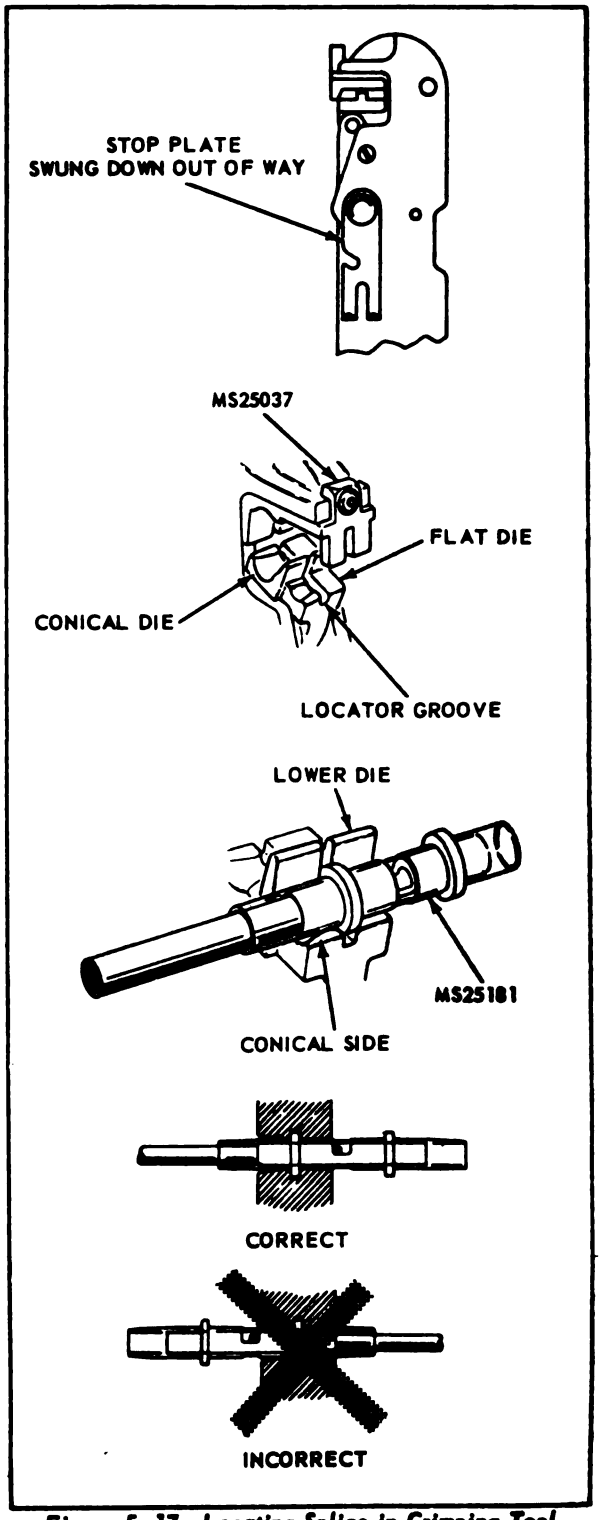


Figure 5-17. Locating Splice in Crimping Tool

g. Reverse position of splice, and repeat steps b through f to crimp other side of splice.

TABLE 5–20

Stripping Length for Small Copper Splices

Wire Size	Stripping Length (Inches)
26 – 24	5/32
22 – 14	7/32
12 – 10	5/16

5–64. SPLICING LARGE COPPER WIRES (SIZES NO. 8 THROUGH NO. 4/0).

5–65. SPLICES. Uninsulated splices are used to join large copper wires of sizes No. 8 through No. 4/0. There is a different splice for each wire size. Uninsulated splices are insulated after assembly with either heat-shrinkable tubing or transparent flexible sleeving to provide electrical and mechanical protection. If using heat-shrinkable tubing method, use procedure described in section XI, paragraph 11–22. If flexible sleeving method is used, cut sleeve to length in accordance with table 5–21. Center sleeve over splice and tie at both ends with cord as shown in figure 5–18.

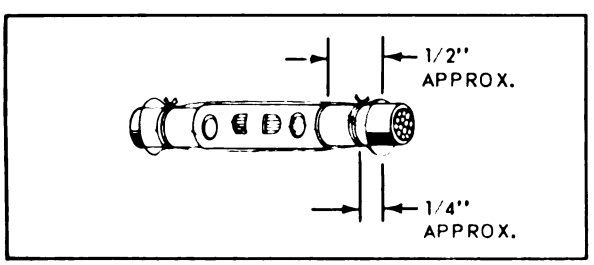


Figure 5–18. Insulating Sleeves for Splices Size 8 and Larger

TABLE 5–21

Length of Insulating Sleeves

Splice Wire Size	Insulating Sleeve Length (in inches)
8	1-15/16
6	2- 1/8
4	2- 1/8
2	2-13/32
1	2-13/32
1/0	2-17/32
2/0	2-25/32
3/0	2-13/16
4/0	2-15/16

5–66. CRIMPING TOOLS. The crimping tools for Burndy large copper splices are AN 3427 (standard tool) and MY28, Y29B and Y29NC. AN 3427 and MY28 are hand tools: Y29B and Y29NC are portable air powered tools which require a different die set for each splice size-these die sets are listed in table 5–22. The portable hydraulic crimping tool head for T & B large copper splices is 13642; it requires a different die set for each splice size, as listed in table 5–23.

Note

Use power tools, if available for large copper splices.

5–67. CRIMPING PROCEDURES. Crimping procedures for hand or power tools are the same as those described in 5–33 through 5–38 for large copper terminal lugs, except that wire is stripped to dimensions given in table 5–24, and crimping operation is done twice, at both ends of splice.

5–68. SPLICING HIGH TEMPERATURE WIRES. Splices for high temperature applications are available in the same wire size ranges as high temperature terminal lugs, (see table 5–14.) The tools and crimping procedures are the same for splices as for terminal lugs. Crimp splice at both ends.

TABLE 5–22

Die Sets Used on Burndy Tools Y29B & Y29NC for Crimping Large Copper Splices

Splice Wire Size	Die Set Number	
	Nest	Indentor
8	DV8L	Y29PL
6	DV6L	Y29PL
4	DV4L	Y29PL
2	DV2L	Y29PL
1	DV1L	Y29PL
1/0	DV25L	Y29PR
2/0	DV26L	Y29PR
3/0	*DV27L	*Y29PR
4/0	*DV28L	*Y29PR

*For tool No. Y29B only, since tool No. Y29NC is not powerful enough for these sizes.

TABLE 5–23

Die Sets Used on T & B Head 13642 for Crimping Large Copper Splices

Splice Wire Size	Indentor	Nest
8	13649M	13651
6	13649M	13652
4	13649M	13653
2	13650M	13654
1	13650M	13655
1/0	13650M	13656
2/0	13650M	13657
3/0	13650M	13658
4/0	13650M	13659

TABLE 5–24

Wire Stripping Lengths for Large Copper Splices

AN Wire Size	Strip Length (inches)
8	7/16
6	1/2
4	1/2
2	5/8
1	5/8
1/0	11/16
2/0	13/16
3/0	13/16
4/0	7/8

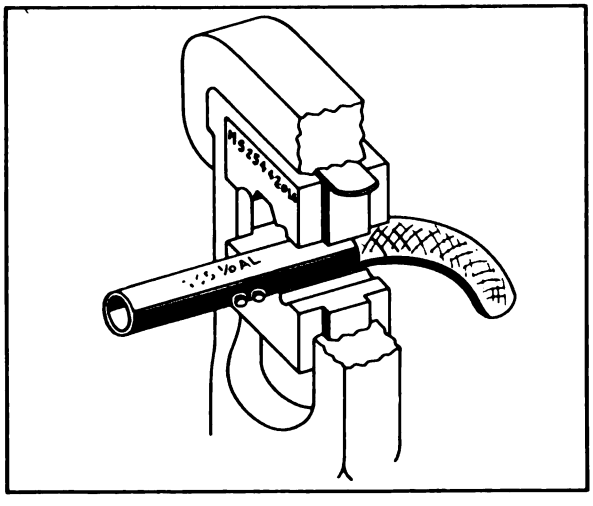


Figure 5–19. Positioning Aluminum Splice in Die Nest

5–69. SPLICING ALUMINUM WIRES. Splice large aluminum wires sizes No. 8 through No. 4/0 with Military Standard splice MS25439. Use the Military Standard power tools listed in table 5–15, with the correct dies from table 5–16. Follow the same procedure as for aluminum terminal lugs outlined in 5–57, positioning the splice in the tool as shown in figure 5–19. Crimp-splice at both ends.

5–70. MULTI-SPLICING. Multi-splicing is the crimping together of three or more wires in a single splice. This is a special application and may be used only when called for on the applicable engineering drawing. See table 5–25 for acceptable combinations of wire sizes. For multi-splicing applications using standard MS25181 splices, the MS21980-128 ferrule is used to hold the wire together during the crimping operation.

5–71. CRIMPING MULTI-SPLICE CONNECTIONS. To terminate multiple conductors in the MS25181 splice to make a multi-splice, use MS21980-128 ferrule with MS17776 and MS25037 crimping tools, with the following procedure.

a. Strip wire ends 1/2 inch.

b. Insert wire in MS21980-128 ferrule to within 3/32 inch, plus or minus 1/32 inch from the insulation of all conductors.

c. Crimp ferrule, using the MS17776 crimping tool.

d. Round ferrule in rounding die of this tool.

e. Trim off excess wire strands protruding through open end of ferrule to extend not more than 1/32 inch beyond ferrule.

f. Insert this assembly into the MS25181-3 splice and crimp with MS25037 crimping tool.

g. Inspect ferrule assembly to insure that it is visible through window, or must not be more than 1/64 inch back under the edge of the splice window.

5–72. INSPECTION OF CRIMPED CONNECTIONS.

5–73. VISUAL INSPECTION. Examine the crimped connection carefully for the following:

a. Indent centered on terminal lug barrel or splice barrels.

b. Indent in line with barrel; not cracked.

c. Terminal lug or splice barrel not cracked.

d. Terminal lug or splice insulation not cracked.

e. Insulation grip crimped.

CAUTION

Do not use any connection which is found defective as a result of the visual inspection. Cut off defective connection and remake using a new terminal lug or splice.

TABLE 5-25

Wire Size Combinations (Per Splice End) for Mulit-Splices

No. of Wires	Wire Size	Combined With: No. of Wires	Wire Size	No. of Wires	Wire Size	Combined With: No. of Wires	Wire Size
2	#22	- - -	- - -	2	#16	- - -	- - -
3	#22	- - -	- - -	3	#16	- - -	- - -
4	#22	- - -	- - -	1	#16	1	#22
2	#20	- - -	- - -	1	#16	2	#22
3	#20	- - -	- - -	1	#16	3	#22
4	#20	- - -	- - -	1	#16	1	#20
1	#20	1	#22	1	#16	2	#20
1	#20	2	#22	1	#16	3	#20
1	#20	3	#22	1	#16	1	#18
1	#20	4	#22	1	#16	2	#18
2	#20	1	#22	2	#16	1	#22
2	#20	2	#22	2	#16	2	#22
2	#20	3	#22	2	#16	1	#20
3	#20	1	#22	2	#16	1	#18
3	#20	2	#22	1	#16	1 #20 and 1	#22
2	#18	- - -	- - -	1	#16	1 #20 and 2	#22
3	#18	- - -	- - -	1	#16	1 #18 and 1	#22
4	#18	- - -	- - -	1	#16	1 #18 and 1	#20
1	#18	1	#22	1	#16	2 #20 and 1	#22
1	#18	2	#22	1	#16	1 #18 and 2	#22
1	#18	3	#22	1	#16	1 #18, 1 #20 and 1	#22
1	#18	4	#22	2	#14	- - -	- - -
1	#18	1	#20	1	#14	1	#22
1	#18	2	#20	1	#14	2	#22
1	#18	3	#20	1	#14	3	#22
2	#18	1	#22	1	#14	1	#20
2	#18	2	#22	1	#14	2	#20
2	#18	3	#22	1	#14	3	#20
2	#18	1	#20	1	#14	1	#18
2	#18	2	#20	1	#14	2	#18
3	#18	1	#22	1	#14	1	#16
3	#18	1	#20	2	#14	1	#22
1	#18	1 #18 and 1	#22	1	#14	1 #20 and 2	#22
1	#18	1 #20 and 1	#22	1	#14	1 #18 and 1	#22
1	#18	2 #20 and 1	#22	1	#14	1 #18 and 2	#22
2	#18	1 #18 and 1	#22	1	#14	2 #20 and 1	#22

5–74. CHECKING DEPTH OF INDENT. Sizes 8 through 4/0 uninsulated terminal lugs and splices crimped with the Military Standard and Burndy tools are checked for depth of indent as follows:

1. Use micrometer or depth indicator with point adapter to measure "T" dimension as shown in figure 5–20.

2. "T" limits for COPPER terminal lugs and splices are listed in tables 5–26 and 5–27.

3. "T" limits for MS25021 and MS25022 ALUMINUM terminal lugs are listed in tables 5–28 and 5–29.

Note

Do not attempt to measure "T" dimensions of insulated terminal lugs. The soft plastic insulation will give a false indication.

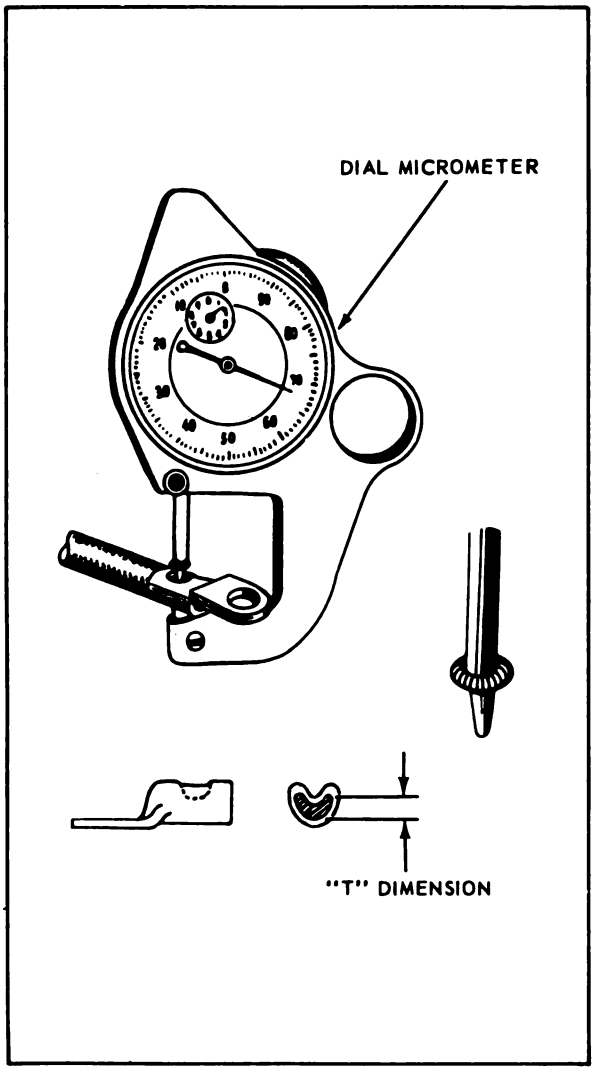


Figure 5–20. Indent Inspection

5–75. When a dial micrometer is not available, a hand micrometer is modified as shown in figure 5–21. The indicated "A" dimension must be subtracted from the micrometer reading to obtain the "T" dimension.

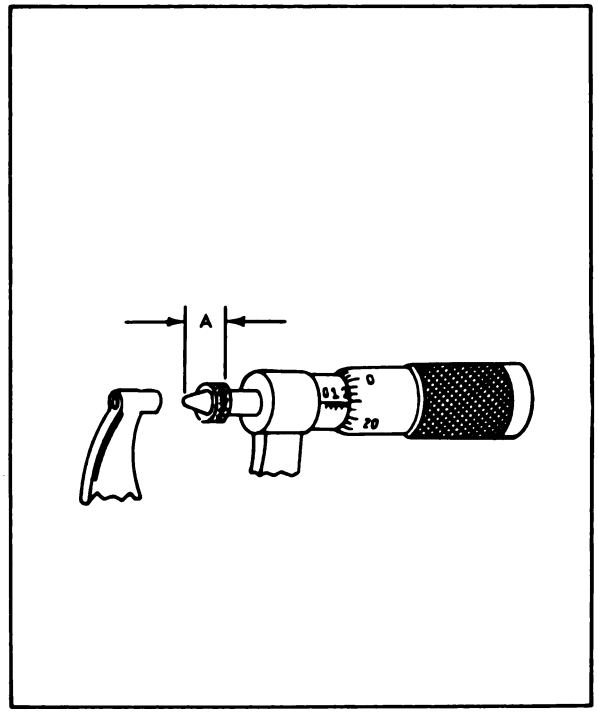


Figure 5–21. Modifying Hand Micrometer for Indent Inspection

TABLE 5–26

"T" Dimensions for Burndy Uninsulated COPPER Splices and Straight and Right-Angle Terminal Lugs

AN Wire Size	"T" Dimensions (in inches) Using AN3427 Min.	Using AN3427 Max.	Using Burndy Tools No. Y29NC, Y29NSC & Y29B Min.	Y29NC, Y29NSC & Y29B Max.
8	.090	.120	.096	.150
6	.090	.120	.109	.150
4	.140	.175	.155	.197
2	.140	.180	.195	.236
1	.220	.260	.227	.281
1/0	.280	.320	.252	.306
2/0	.280	.330	.270	.330
3/0	.365	.410	.335	.395
4/0	.410	.455	.320	.380

TABLE 5-27

"T" Dimensions for MS25189 COPPER (Flag) Terminal Lugs

"T" Dimensions (in inches)

AN Wire Size	Using AN3427 Tool		Using Burndy Tools No. Y29B & Y29NSC	
	Min.	Max.	Min.	Max.
8	.130	.170	.180	.205
6	.130	.180	.205	.235
4	.205	.260	.270	.315
2	.265	.318	.270	.315
1/0	.325	.378	*.340	.440
2/0	.390	.450	.405	.465
4/0	.510	.570	.500	.580

*For Tool Y29B these dimensions are .310 – .440

TABLE 5-28

"T" Dimensions for MS25021 ALUMINUM (Straight) Terminal Lugs

"T" Dimension (in inches)

AL Wire Size	Using MS25020 Tool		Using Burndy Tools No. Y29B, Y29NC, Y29NSC	
	Min.	Max.	Min.	Max.
8	.098	.123	.098	.168
6	.125	.150	.125	.150
4	.141	.176	.136	.176
2	.259	.294	.171	.240
1	.290	.320	.204	.280
1/0	.340	.400	.232	.336
2/0	.375	.420	.290	.390
3/0	.380	.435	.310	.400
4/0	.410	.485	.380	.479

TABLE 5-29

"T" Dimensions for MS25022 ALUMINUM (Flag) Terminal Lugs

"T" Dimension (in inches)

AL Wire Size	Using MS25020 Tool		Using Burndy Tools No. Y29B, Y29NC, Y29NSC	
	Min.	Max.	Min.	Max.
8	.145	.200	.155	.185
6	.205	.245	.190	.220
4	.265	.305	.260	.290
2	.272	.305	.230	.280
1	.338	.373	.255	.305
1/0	.391	.423	.255	.315
2/0	.370	.406	.345	.405

SECTION VI

TAPER PIN TERMINATIONS

6–1. INTRODUCTION.

6–2. GENERAL. Taper pins are used as wire terminations, in assembly with receptables in taper pin blocks or in connectors, where space and weight are considerations, and where easy relocation of wiring is desirable. Taper pins are not to be considered as a quick-disconnect, but are used as a permanent electrical connection capable of being easily serviced and re-located.

6–3. SCOPE. This section describes and illustrates the recommended procedures for crimping taper pins to electrical wire; for inserting taper pins into their mating receptacles; and for extracting taper pins from receptacles. It also describes and illustrates the tools used to accomplish these procedures.

6–4. DESCRIPTION. Taper pins are pre-insulated, or uninsulated; both types are available with or without an insulation grip. The pins described in this section are the .053 size (.053 inch diameter at the small end of the taper) as made by AMP and Burndy. Also included is a special version of the standard AMP taper pin, used as termination for the hard molded harness described in section XII.

6–5. TAPER PIN TOOLS.

6–6. CRIMPING TOOLS. Taper pins are attached to electrical wires by crimping with a manually operated portable tool, in which a ratchet controls the crimping cycle and prevents the tool handle from opening before the crimp is fully accomplished. See figure 6–1. Portable power and automatic feed tools are also available.

6–7. INSERTION TOOLS. (See figure 6–2a.) Taper pins are inserted into mating receptacles with an insertion tool which provides the exact force necessary to lock the pin and receptacle together. Insertion tools are available with a captivating device that prevents their being withdrawn until the taper pin has been fully inserted. AMP tools have an optional pull test feature which applies a force to ten to twelve pounds to test the completed connection.

6–8. EXTRACTION TOOLS. See figure 6–2b. Use of an extraction tool allows the taper pin to be removed from the mating receptacle without damage to either part.

Note

Normally a formed taper pin may be extracted and re-inserted into the same receptacle a maximum of five times. If by careful handling the pin remains undamaged the number of insertions may be increased. Solid pins carefully handled should be capable of twenty re-insertions.

6–9. SPECIAL INSERTION-EXTRACTION TOOL. See figure 6–3. This tool, designed for use with the Chance Vought special AMP taper pins incorporates three features in the one tool: insertion of pins into receptacles, pull-testing, and extraction of pins from receptacles. The tool cannot be disengaged until the pins are fully inserted and pull-tested.

CAUTION

Do not use this tool with any other taper pins.

6–10. CRIMPING PROCEDURES.

6–11. CRIMPING PROCEDURE FOR STANDARD AMP TAPER PINS. Attach standard AMP taper pins, insulated or uninsulated, to electrical wire as follows:

a. Cut wire to length, and strip to dimension given in table 6–1.

b. Select the proper crimping tool from table 6–2 or table 6–3.

Note

Omit step c for uninsulated terminals

c. Check insulation grip with both insulation crimping adjustment pins in the Number 3 position. See figure 6–4. Place taper pin in crimping jaws with unstripped wire inserted in insulation grip portion of taper pin. Crimp, then bend wire back and forth holding taper pin firmly. If wire pulls out, repeat test with pins in remaining positions until desired insulation grip is obtained.

d. Open crimping jaws of tool by squeezing handles until ratchet releases.

e. Holding the tool with the unblackened link uppermost, insert the taper pin from the under side so that the pin shoulder rests against the locator in the tool. See figure 6–5.

f. Close handles until the jaws just grip the taper pin barrel, and insert the stripped wire into the barrel.

g. Hold the wire firmly in place and close the tool handles until the ratchet releases. Remove the crimped assembly.

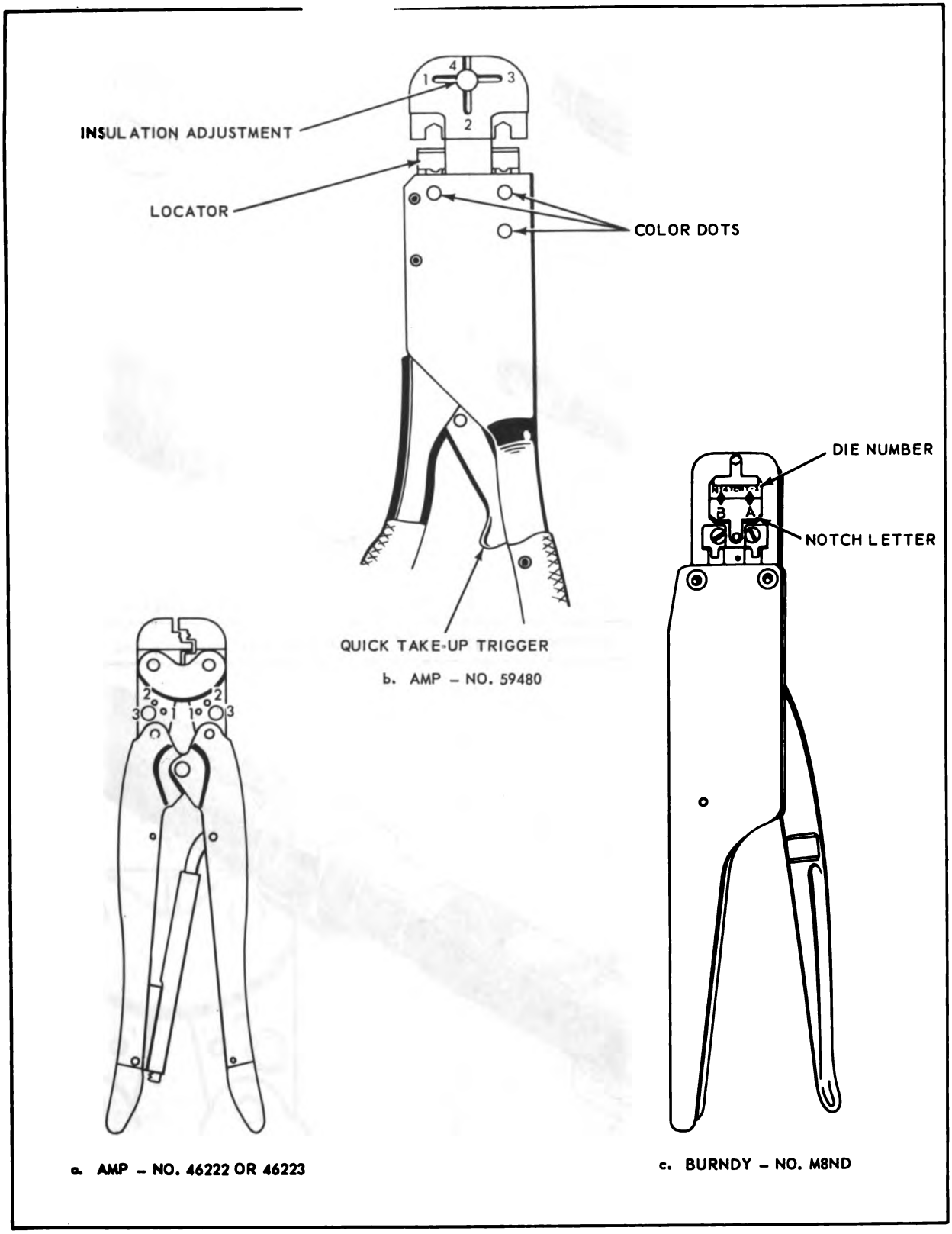


Figure 6–1. Crimping Tools for Taper Pins

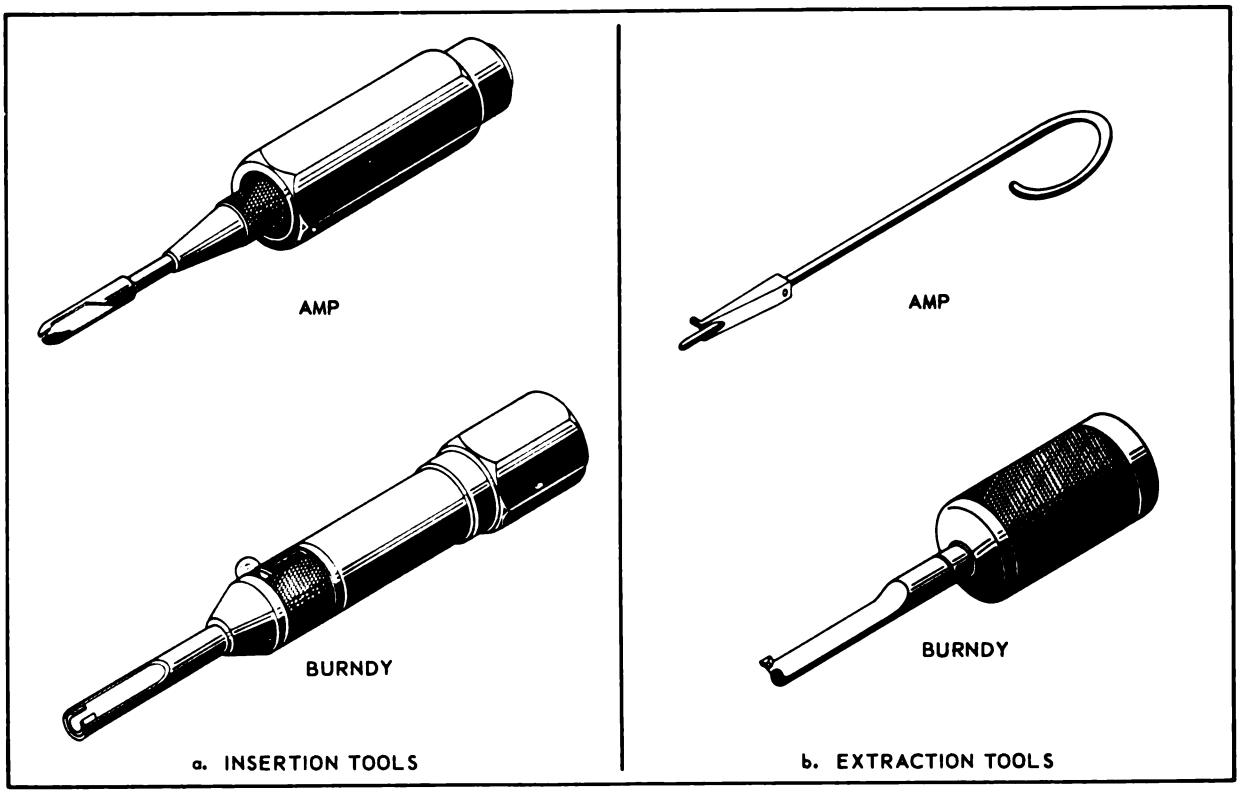


Figure 6–2. Insertion and Extraction Tools for Taper Pins

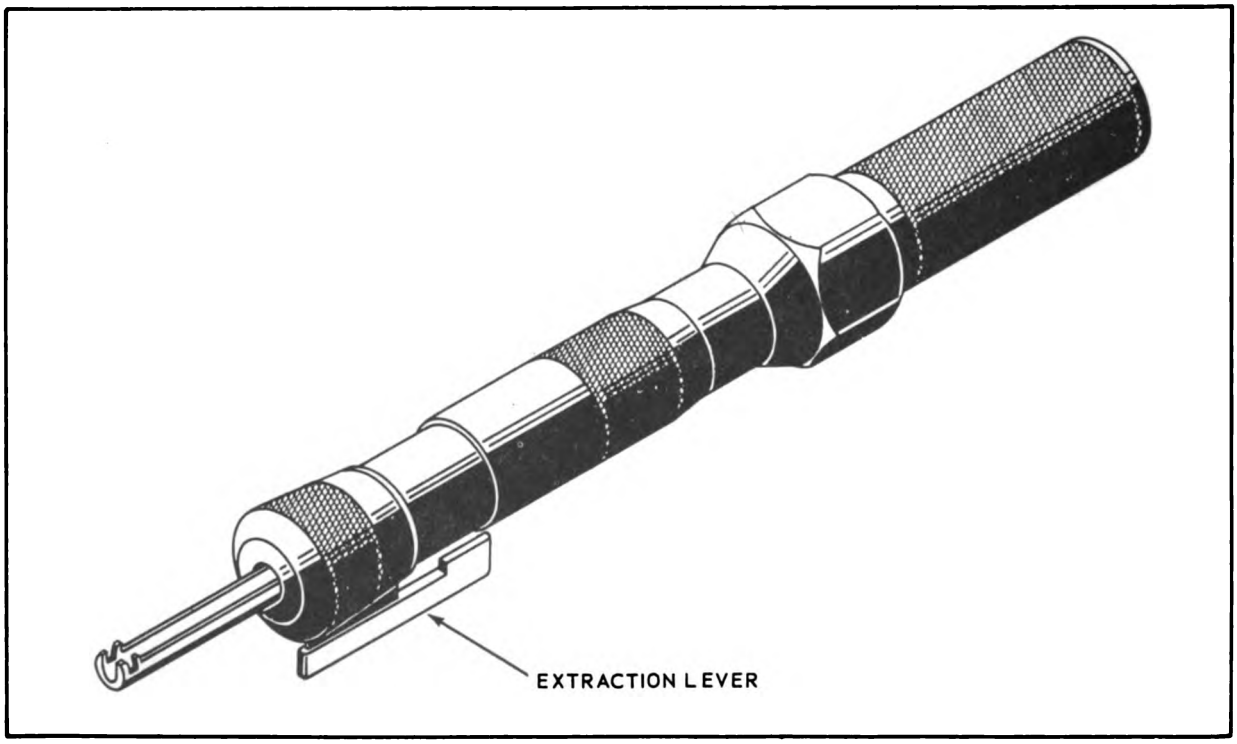


Figure 6–3. AMP Combination Insertion – Extraction Tool No. 380565

TABLE 6–1

Stripping Lengths for Taper Pin Terminations

Wire Size (AN)	Stripping Length (Inches)
#24 – #22	5/32
#20 – #18	3/16
#16 – #14	3/16

TABLE 6–3

Taper Pin Tooling – AMP Standard 53 Series, Pre-Insulated

Wire Size (AN)	Crimping Tool	Insertion Tool*	Extraction Tool
24 – 22	46222	380431–1 or –2	380305–1
20 – 18	46223	380431–1 or –2	380305–1
16	46223	380431–1 or –2	380305–1

*–1 numbers for receptacles in resilient inserts
–2 numbers for receptacles in rigid inserts

TABLE 6–2

Taper Pin Tooling – AMP Standard 53 Series, Non-Insulated

Wire Size (AN)	Insulation Dia. Range	Crimping Tool	Insertion Tool*	Extraction Tool
24 – 22	.040 – .060	48698	380310–1 or –2	380305–1
	.065 – .080	47042	380310–3 or –4	380305–1
20 – 18	.060 – .080	45766	380310–3 or –4	380305–1
	.080 – .100	47043	380310–3 or –4	380305–1
18 – 16	.100 – .125	47044	380310–3 or –4	380305–1

*–1 or –3 numbers for receptacles in resilient inserts.
–2 or –4 numbers for receptacles in rigid inserts.

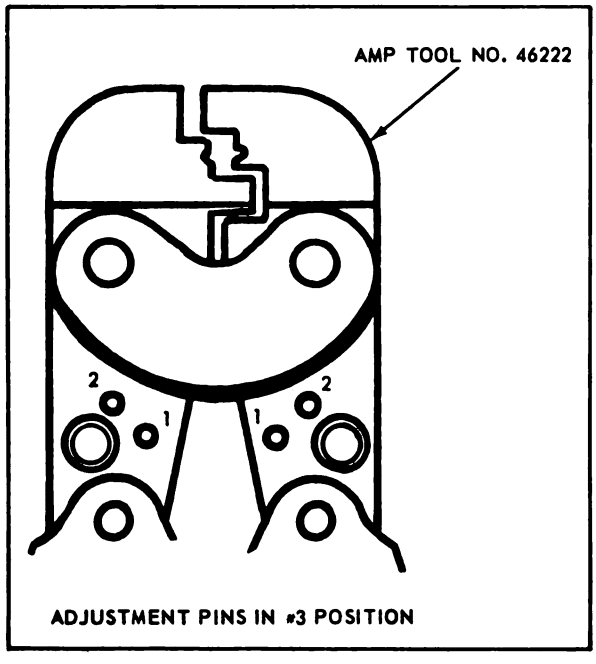


Figure 6–4. Crimping Tool Insulation Adjustment

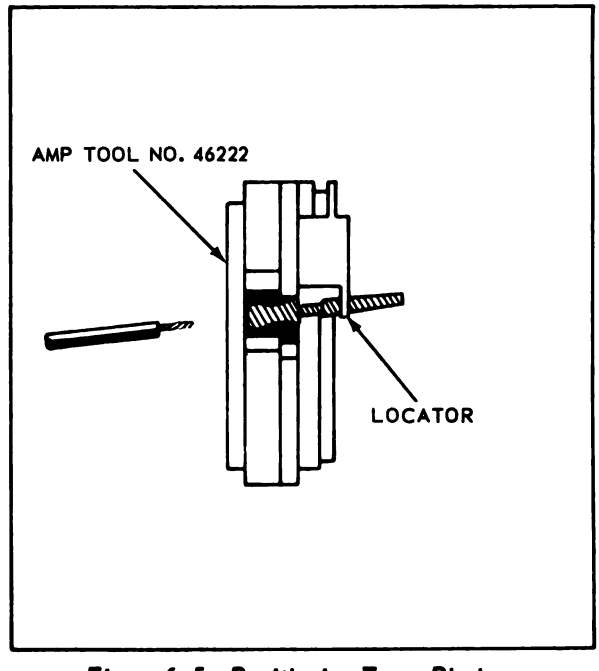


Figure 6–5. Positioning Taper Pin in AMP Crimping Tool

6–12. CRIMPING PROCEDURE FOR BURNDY TAPER PINS. Using the proper tool and die from table 6–4, crimp Burndy taper pins on wire following the procedure outlined in 6–11, omitting step c. Make sure the taper pin is inserted into the porper die notch as listed in table 6–4. Refer to figure 6–1b.

6–13. CRIMPING PROCEDURE FOR SPECIAL AMP TAPER PINS. Before crimping taper pin to wire, determine the tool insulation adjustment as follows: (Refer to figure 6–1c.)

a. Loosen the Allen head screw at the top of the crimping tool listed in table 6–5.

TABLE 6–4

Taper Pin Tooling – Burndy .053 Series

Wire Size (AN)	Insulation Dia. Range	Crimping Tool M8ND (Die Set)	(Notch)	Insertion Tool	Extraction Tool
14 – 16	.088 – .113	N14TCHT–1	A	TT14	TX14
	.056 – .083	–1	A	TT14	TX14
	.095 – .123	–11	A	TT14G1	TX14
	.072 – .098	–1	A	TT14	TX14
	.050 – .076	–1	A	TT14	TX14
18–20–22	.088 – .115	N14TCHT–1	A	TT14	TX14
	.056 – .083	–1	A	TT14	TX14
	.095 – .123	–11	A	TT14G1	TX14
	.072 – .098	–1	A	TT14	TX14
	.050 – .076	–1	B	TT14	TX16
22–24–26	.088 – .113	N14TCHT–1	A	TT14	TX14
	.072 – .098	–1	A	TT14	TX14
	.050 – .076	–1	B	TT16	TX16
	.040 – .057	–1	B	TT16	TX16
	.029 – .040	–1	B	TT16	TX16

TABLE 6–5

Taper Pin Tooling – Special AMP 53 Series

Wire Size (AN)	Crimping Tool	Combination Insertion–Extraction Tool
#24 – 22	59480	380565–6
#18 – 20	59480	380565–6
#16	59480	380565–6

b. Turn insulation adjustment pin to position #4.

c. Place taper pin in the die above the matching color dot so that the taper pin collar is flush against the locator and the barrel is seated on the crimping die.

d. Insert a piece of unstripped wire of the size to be used into the terminal barrel and crimp. Remove assembly.

e. Check insulation grip by bending wire back and forth. If wire is firmly gripped lock the insulation crimping die.

f. If wire is loose, repeat above procedure with insulation adjustment pin successively in positions #3, #2 and #1 until satisfactory grip is obtained. Lock crimping die.

g. Cut wire to length and strip to dimension given in table 6–1.

h. Insert the taper pin in the crimping die above the color dot matching the pin insulation. Make sure the taper pin collar is firmly against the locator, and that the barrel is securely seated in the crimping die.

i. Press the quick take-up trigger and squeeze the tool handles just enough to hold the terminal barrel firmly in the die.

j. Insert the stripped wire into the taper pin barrel; make sure the insulation is hard against the inside chamfer of the pin.

k. Hold the wire firmly in place, and close the tool handles until the ratchet releases.

l. Open handles and remove the crimped assembly.

6–14. INSERTION OF TAPER PINS.

6–15. INSERTING AMP STANDARD TAPER PINS INTO RECEPTACLES. Using the correct tool from tables 6–2 or 6–3, proceed as follows:

a. Slip the narrow slot at the front of the tool tip over the wire barrel of the taper pin. The extreme end of the tool tip should butt against the stop at the front of the barrel.

b. Hold the wire against the tool body with one finger.

c. Hold the taper pin block or connector firmly against a flat surface, and insert the taper pin into the receptacle.

d. With the tool (and wire) perpendicular to the receptacle face, push straight in until the taper pin is in place.

CAUTION

Insert taper pin with one steady stroke; do not use more than one stroke as this may damage the receptacle.

e. Tilt the tool slightly away from the slot side, and slide it off the taper pin.

f. If pull test is desired, before removing the tool from the taper pin, pull straight back slowly on the hexagonal sleeve of the tool, until the sleeve just barely moves. Stop pulling; if the taper pin remains in place the connection is good. If the taper pin pulls out, reinsert it. If it still pulls out, the receptacle and pin should be replaced.

6–16. INSERTING BURNDY TAPER PINS INTO RECEPTACLES. Insert Burndy taper pins into their matching receptacles as follows:

a. Select the proper tool from table 6–4.

b. Place the taper pin in the tool from the side, and turn the tool sleeve to enclose the pin in the tool.

c. Insert the taper pin into the receptacle following the procedure outlined in 6–15, steps b through e.

d. Pull-test the inserted taper pin with Burndy TR tool, shown in figure 6–6. Place the tip of the test tool around the inserted taper pin and apply tension. If the pin is firmly seated the test tool will release without disturbing the connection.

6–17. EXTRACTION OF TAPER PINS.

6–18. EXTRACTING TAPER PINS FROM RECEPTACLES. Using the extracting tools listed in tables

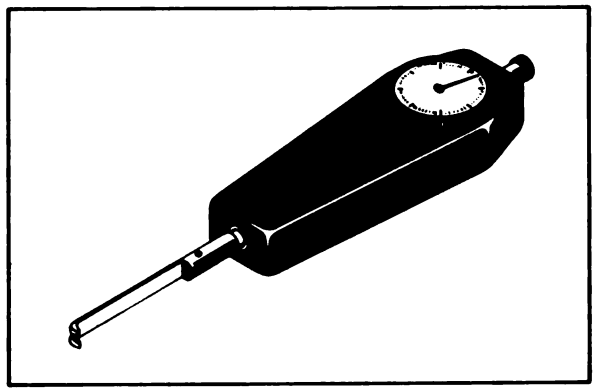


Figure 6–6. Pull Test Tool (Burndy TR)

6–2, 6–3, or 6–4, extract taper pins from receptacles as follows:

a. Insert the forked foot of the tool under the taper pin collar.

b. Pull back slightly on the handle to extract the pin.

6–19. INSERTING AND EXTRACTING SPECIAL AMP TAPER PINS. The special AMP taper pins used with Chance Vought's molded harness are inserted and extracted with the tool described in 6–9. The procedure for using this tool is as follows: (Refer to figure 6–3).

a. Insertion:

1. Hold the knurled tip part of the tool in one hand, and with the other hand pull the knurled tool handle back (away from tip) as far as possible. Place the taper pin with wire attached in the cavity of the tool tip, with the taper pin shoulder lodged in the shoulder slot adjacent to the tip.

2. Holding the pin firmly in the tip with one hand, push the tool handle forward (toward the tip) so that the pin and attached wire are held captive by the key.

3. With the taper pin receptacle block secured to a firm backing plate, position the taper pin into the receptacle.

4. Make sure that the tool, taper pin and receptacle are all in a straight line, with tool perpendicular to the plane of the receptacle block; then push the tool handle steadily toward the receptacle block until the tool trips. A single stroke only is required to properly secure the taper pin. Added strokes may limit the re-insertion life of the taper pin. (See 6–8 note)

5. Pull test the connection by pulling slowly and steadily on the knurled tool handle until the key releases. If the taper pin remains in place, the connection is secure. If the pin pulls out, re-insert and test again. If it pulls out again, replace the taper pin.

6. When a secure connection has been made, remove the tool by sliding the tip sideways away from the shoulder of the pin, and carefully disengage the tool

from the inserted taper pin, adjacent pins and block barriers.

b. Extraction:

1. Engage the taper pin with the tool in the same way as the insertion procedure.

2. Push the extraction lever down to extract the taper pin.

3. Raise tool to withdraw taper pin from receptacle.

6–20. CHECKING INSERTION-EXTRACTION TOOL. The correct trip pressure (16 to 17 pounds) and the correct pull test pressure is set into the tool at the factory and locked. Special calibration equipment is required to carry out this procedure. Adjustment and calibration of this tool can be made only at the factory or at a factory-authorized calibration station. Approximate force measurements may be obtained in the field as follows:

a. Test the trip pressure on a properly zeroed scale reading directly in pounds. Place the tip of the tool at the center of the plate or pan, holding the tool perpendicular, and push slowly downward until the tool trips. Scale should read 16 to 17 pounds.

b. Measure the pull-test tension with a spring scale. Tie the tip of the tool to the scale and using a slow steady pull, note the pull in pounds required to snap the locking key into the open position. Scale should read 8–1/2 to 12–1/2 pounds.

SECTION VII

THERMOCOUPLE WIRE SOLDERING AND INSTALLATION

7–1. INTRODUCTION.

7–2. GENERAL. Thermocouples are used throughout the aircraft to detect and measure temperature changes. Thermocouples are prefabricated into spark plug gaskets, bayonets for insertion into oil sumps and probes for use in exhaust stacks. These thermocouples are supplied with short leads, usually 12 inches long, and end in terminals such as AN5548 or AN5539. The installation mechanic fabricates extension leads to carry the voltages generated by the thermocouple to the indicating instruments. The components of a thermocouple system are designed to have a high degree of accuracy; correct installation by a good mechanic will maintain this accuracy.

7–3. SCOPE. This section describes and illustrates recommended procedures for fabrication and installation of thermocouple extension leads.

7–4. The importance of good workmanship in the fabrication and installation of thermocouple wires cannot be over-emphasized. A good mechanic is careful to be neat and thorough in soldering and installing wires.

7–5. REFERENCE SPECIFICATIONS AND DRAWINGS.

O-F-499	Flux, Brazing, Sliver Alloy, Low Melting Point
QQ-S-561	Solder, Silver
QQ-S-571	Solder, Lead Alloy, Tin-Lead Alloy, and Tin Alloy
MIL-T-713	Twine and Tape, Lacing and Tying, (For use in Electrical and Electronic Equipment)
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-T-5679	Thermocouple Leads, Iron and Constantan, Chromel and Alumel, and Copper and Constantan, Installation of
MIL-W-5845	Wire, Electrical, Iron and Constantan, Thermocouple
MIL-W-5846	Wire, Electrical, Chromel and/or Alumel, Thermocouple
MIL-W-5908	Wire, Electrical, Copper and Constantan, Thermocouple
MIL-S-6872	Soldering Process, General Specification for
AN5537	Connector Assembly-Thermocouple Lead
AN5538	Terminal–Thermocouple Lead Soldering
AN5539	Terminal–Thermocouple, Brass
AN5542	Terminal–Thermocouple
AN5548	Terminal–Lug, Thermocouple, Chromel and Alumel
AND10406	Thermocouple Leads–Iron–Constantan, Installation of
MS33560	Thermocouple Leads, Chromel and Alumel 8 ohm System, Copper and Constantan, 22 ohm system, Installation of
MS33599	Thermocouple Leads–Iron–Constantan, 2 ohm and 8 ohm System, Installation of

7–6. DESCRIPTION – THERMOCOUPLE WIRE LEADS. See figure 7–1. Thermocouple extension wires are paired in a braided jacket and color-marked as listed in table 7–1. The material for extension leads is the same as the thermocouple material. Iron-constantan extensions are used for iron-constantan thermocouples, chromel-alumel extensions for chromel-alumel thermocouples, and copper-constantan extensions for copper-constantan thermocouples.

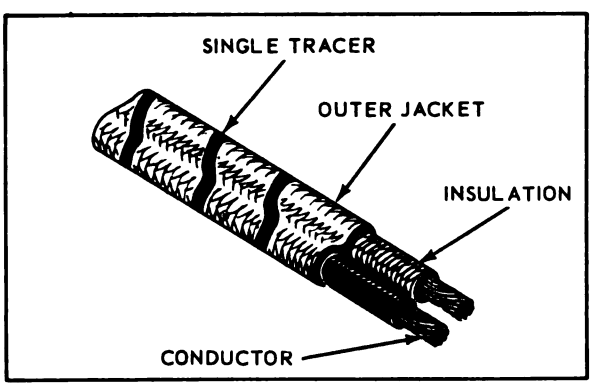


Figure 7–1. Thermocouple Wire

7–7. DESCRIPTION-THERMOCOUPLE TERMINALS AND CONNECTOR. See figure 7–2. Selection of terminals for thermocouple wiring is governed by AND Drawing 10406, and Military Standard Drawings MS-33560 and MS33599. The selection is based on location within the airframe, and on temperature conditions. Hot areas are those subject to high temperature, such as engine section, exhaust pipe, etc. Cool areas are those on the side of the firewall away from the engine or other heat producing elements. Where the temperature does not exceed 250°F, use terminals listed in table 7–2 (dervied from Drawings AND10406, MS33560 and MS 33599).

TABLE 7-1

Thermocouple System

a. Iron Constantan Systems

Conductor	Insulation Color	Polarity
Iron	Black	Positive (+)
Constantan	Yellow	Negative (–)

	Type II – 8 ohms per 100 ft.		Type III – 8 ohms per 200 ft.	
	Class A	Class B	Class A	Class B
Outer jacket base color:	Light blue	Light blue	Light blue	Light blue
Tracer color:	None	One red	Two Black	Two red
Temperature limit of insulation:	120°C (248°F)	230°C (446°F)	120°C (248°F)	230°C (446°F)

b. Chromel–Alumel System

Conductor	Insulation Color	Polarity
Chromel	White	Positive (+)
Alumel	Green	Negative (–)

	Type II, Class A 7 ohms per 25 ft.	Type III, Class A 7 ohms per 50 ft.	Type IV, Class A 7 ohms per 100 ft.
Outer jacket base color:	White	White	White
Tracer color:	One green	Two green	Three green
Temperature limit of insulation:	315°C (600°F)	315°C (600°F)	315°C (600°F)

c. Copper–Constantan System

Conductor	Insulation Color	Polarity
Copper	Red	Positive (+)
Constantan	Yellow	Negative (–)

	Type II – 7 ohms per 200 feet	
	Class A	Class B
Outer jacket base color:	Black	Black
Tracer color:	One White	Two White
Temperature limit of insulation:	120°C (248°F)	230°C (446°F)

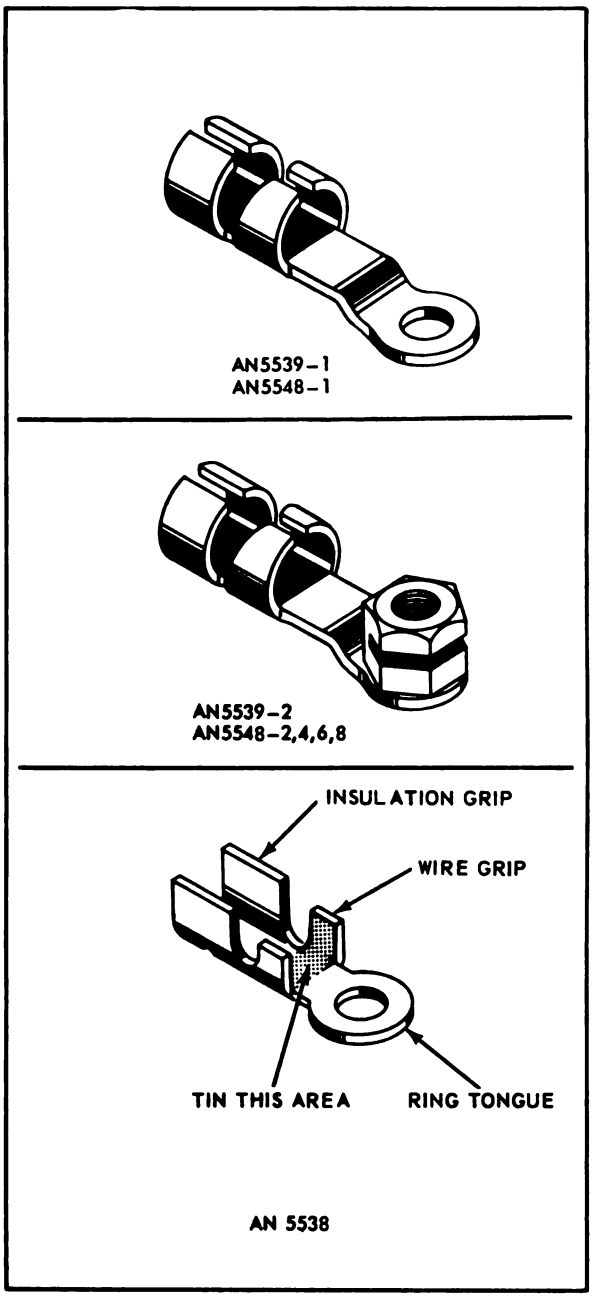


Figure 7–2. Thermocouple Terminals

TABLE 7–2

Thermocouple Terminals

	Hot Areas (Silver Soldered)	Cool Areas (Tin-lead Soldered)
Iron–Constantan	AN 5539	AN 5538
Chromel-Alumel	AN 5548	AN 5538

Dash letters after basic numbers indicate whether terminal is plain or lock type, except for AN 5538, where dash number indicates change in size only.

CAUTION

Do not use solderless terminals on thermocouple wire unless specified in applicable engineering drawing.

Thermocouple connector An 5537 as shown in figure 7–3 is used to carry thermocouple connections through firewalls. This is a plug and jack connection, supplied with an insulating plate for attachment to the firewall. Plugs and jacks are supplied in chromel-alumel or iron-constantan combinations. The jack part of the connector is installed on the cool side of the firewall. The pin plug part of the connector is installed on the hot side of the firewall.

7–8. DESCRIPTION - THERMOCOUPLE CONTACTS IN MS CONNECTORS. MS type connectors may be supplied with iron-constantan or chromel-alumel contacts in sizes #12, #16 or #20 in some insert arrangements for thermocouple connections. These contacts are coded to identify the material. (See table 7–3).

7–9. DEFINITIONS.

a. Soft solder a mixture of 60% tin and 40% lead, as specified in Federal Specification QQ-S-571. It may be in bar form to be melted for tinning, or in the form of rosin core solder wire for use with soldering iron.

b. Hard solder-sliver alloy with flow point at approximately 635°C (1175°F), as specified in Federal Specification QQ-S-561.

c. Solf solder flux. For use with soft solder, flux is pure water-white rosin (Federal Specification LLL-R-626), if necessary powdered and mixed to a pastelike consistency with denatured alcohol. Other, more active soldering fluxes may be necessary. See 7–26 for details.

d. Hard solder flux. For use with hard solder, flux is borax or other similar material (Federal Specification O-F-499) mixed to a paste-like consistency with water.

e. Soldering and brazing. For purposes of this section, the term "soldering" includes soft soldering, silver (hard) soldering and brazing.

7–10. THERMOCOUPLE WIRE PREPARATION.

7–11. CUTTING AND IDENTIFYING THERMOCOUPLE WIRE. Cut thermocouple wire with diagonal pliers to length specified in drawing. Cut so that end is clean and square. Identify wire with sleeves as described in section II, paragraph 2–24. If outer covering is removed more than three inches from termination, install sleeve just back of serving at branching point (refer to 7–24).

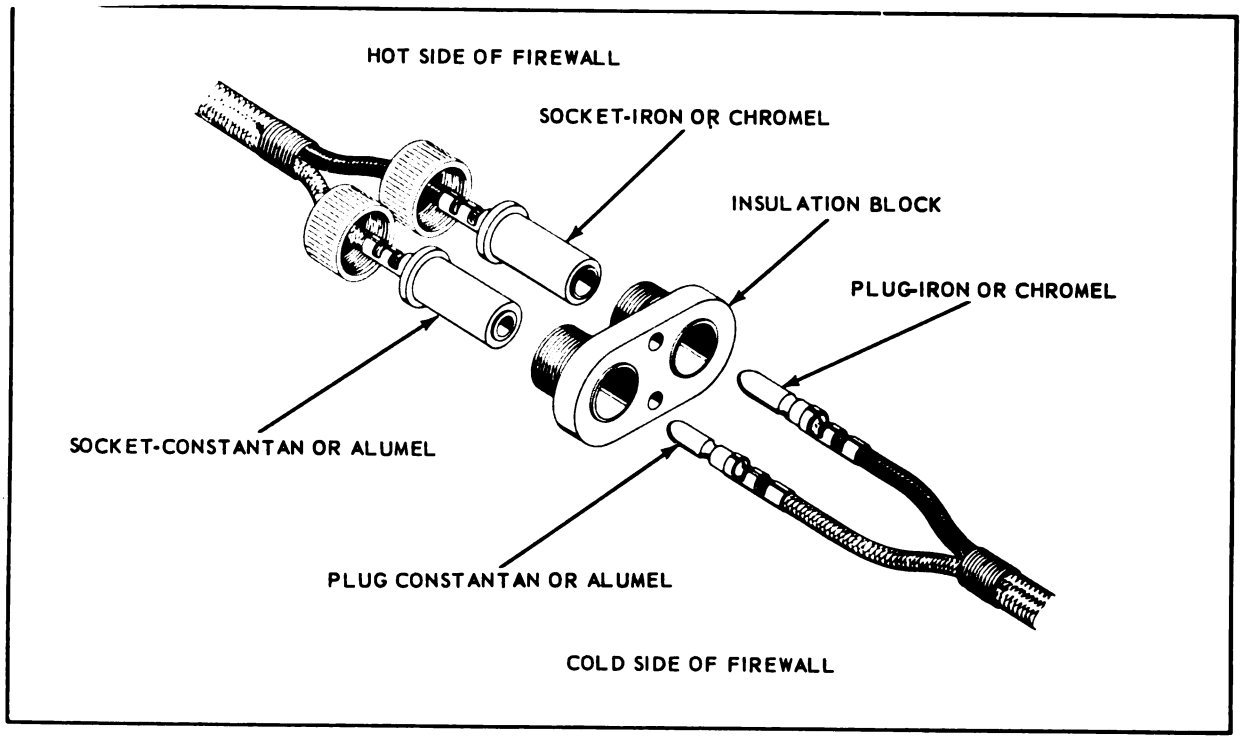


Figure 7–3. Thermocouple Connector Assembly (AN5537)

7–12. STRIPPING THERMOCOUPLE WIRE. Remove outer covering of thermocouple wire with a knife by slitting between parallel conductors and trimming the fabric braid with scissors or diagonal pliers. The stripping dimensions for each use are shown in figures 7–4 through 7–6. Note that longer stripped lengths are required if the wires are to be resistance tinned.

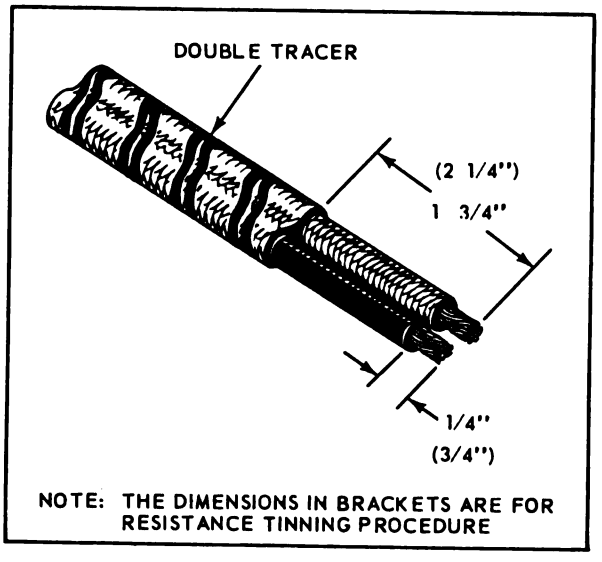


Figure 7–4. Stripping Thermocouple Wire for Terminal and for AN 5537 Connector Installation

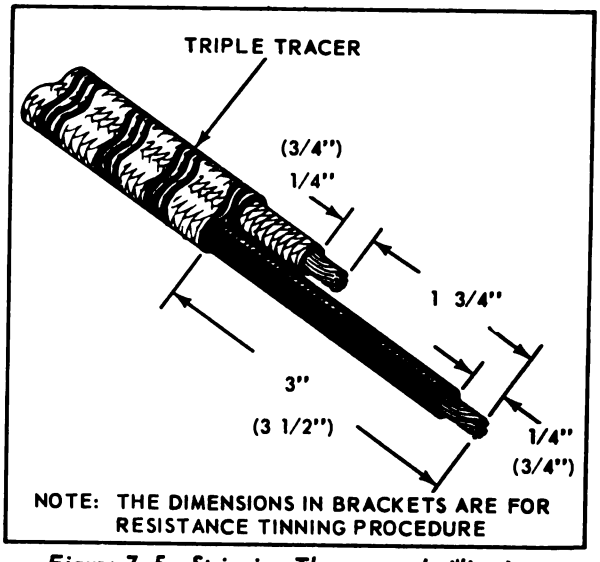


Figure 7–5. Stripping Thermocouple Wire for Splice Installation

7–13. Use a hand stripper, as illustrated in section II, figure 2–21, for removing the primary insulation from each conductor.

CAUTION

Do not cut or nick strands of the conductor.

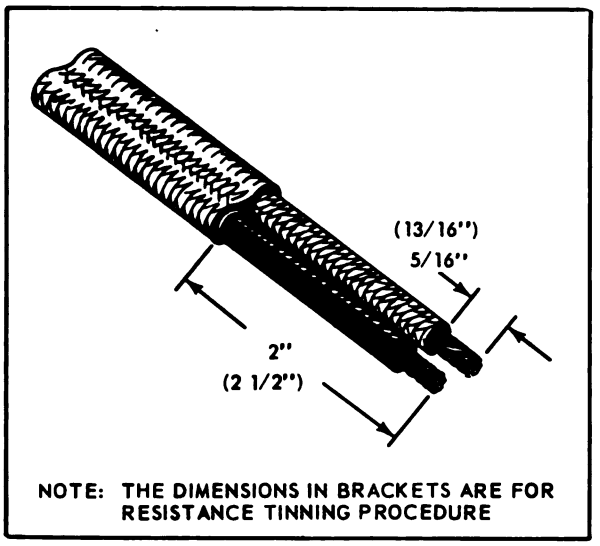


Figure 7–6. stripping Thermocouple Wire for MS Connector Installation

7–14. CLEANING WIRE PRIOR TO SOLDERING. Clean stripped conductor, if necessary, as follows: Remove grease and dirt by washing with Stoddard's solvent. Rinse in methylene chloride for no longer than five seconds.

CAUTION

Do not use extra heat and special fluxes as a sibstitute for clean soldering surfaces.

7–15. HARD SOLDERING THERMOCOUPLE WIRE.

7–16. TORCH TINNING WITH SILVER SOLDER. Before wires are soldered to terminals or other connections they are tinned. The inability to obtain a good tinned surface indicates that the wire was not clean. The procedure for torch tinning is as follows: (See figure 7–7)

a. Dip half of exposed, clean conductor into hard solder flux.

b. Protect wire insulation with notched copper sheet shield, to prevent scorching.

c. Apply flame to wire until flux bubbles. Then feed small amount of silver solder in wire form to fluxed area while flame is kept there. After the silver solder has flowed remove the flame and allow the wire to cool in the air.

CAUTION

Silver solder will flow and adhere to conductor at approximately 635°C (1175°F). Avoid greater heat then necessary. Excess heat will decompose flux and prevent alloying of silver solder to the wire.

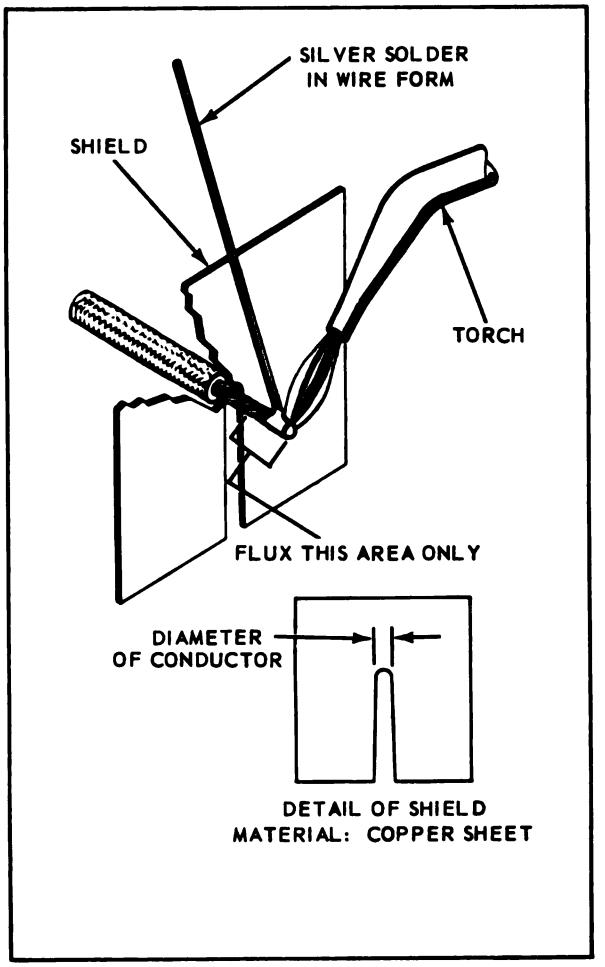


Figure 7–7. Torch Tinning Thermocouple Wire

7–17. DIP TINNING WIRE WITH SILVER SOLDER. Thermocouple wires can be dip tinned in molten silver solder if a solder pot capable of maintaining the required 635°C (1175°F) heat is available. The process is similar to that used in dip tinning copper wire in soft solder as described in section II, paragraphs 2–53. The procedure for dip tinning with silver solder is as follows: (See figure 7–8)

a. Dip half of exposed, clean conductor into hard solder flux.

b. Dip fluxed conductor into solder pot, Do not dip conductor deeper than one half of exposed area.

Note

Powered borax sprinkled over top of molten solder will retard oxidation of solder and aid alloying of silver solder to the wire.

c. After solder has flowed between strands, remove the wire and allow it to cool in air.

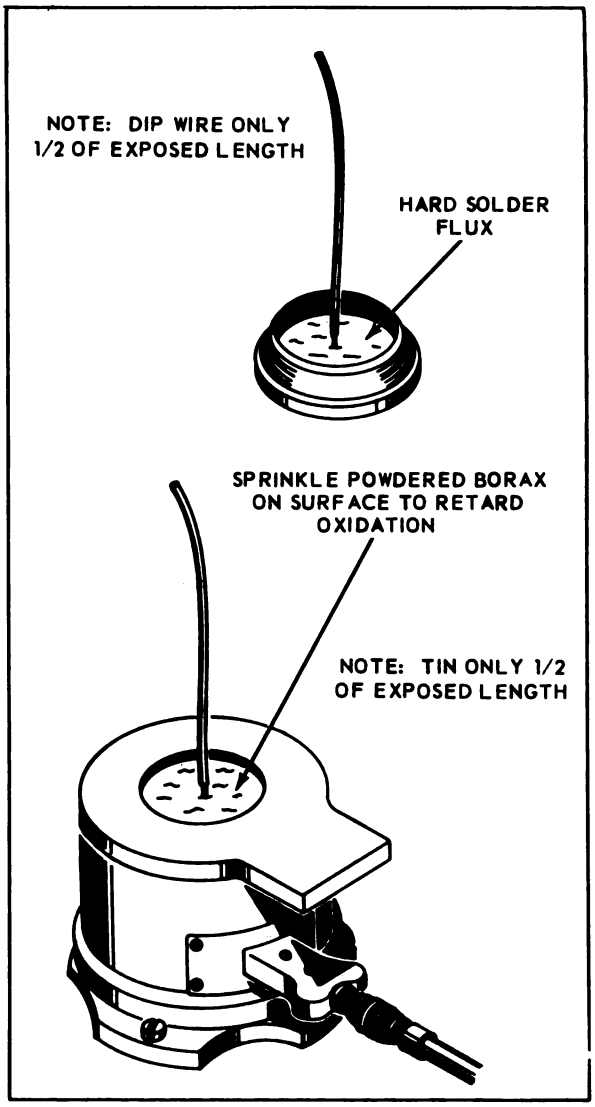


Figure 7–8. Dip Tinning Thermocouple Wire in Silver Solder

7–18. RESISTANCE TINNING WIRE WITH SILVER SOLDER. Electrical resistance heat is a good method for silver soldering thermocouple wires. Use a unit which has a capacity of 1000 watts. See figure 7–9. Wire which is to be tinned by means of electrical resistance should be stripped 1/2 inch longer than wire which is to be dip tinned or torch tinned. The extra 1/2 inch provides a holding area which is removed after tinning is complete. See figures 7–4 through 7–6 for stripping dimensions. The procedure for resistance tinning is as follows:

a. Apply hard solder flux to area to be tinned. This is an area about 1/8 inch long as shown in figure.

b. Grasp end of wire in resistance heating pliers. Grasp wire only as shown.

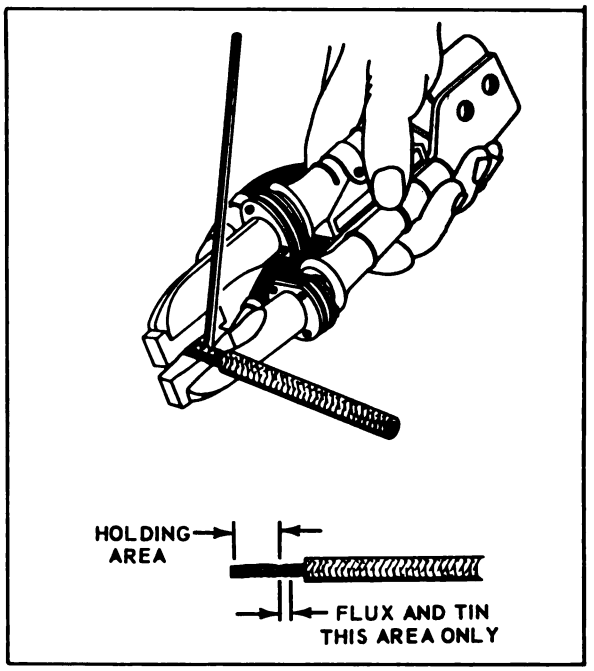


Figure 7–9. Resistance Heating to Tin Wire

c. Apply current for approximately five seconds and then touch silver solder wire to area previously fluxed.

d. After solder has flowed between strands, shut off the current and allow the wire to cool in air.

CAUTION

Do not overheat the wire by allowing the current to remain on longer than necessary to flow the silver solder.

e. Trim off the holding area of the exposed conductor. The conductor should be trimmed with diagonal pliers to the point of tinning.

7–19. TINNING TERMINALS WITH SILVER SOLDER. Tin only section of thermocouple terminals inside wire grip as shown in figure 7–2. Terminals for silver soldering should not be plated.

CAUTION

Do not allow any flux or solder to get on the insulation grip or on the ring tongue.

a. With a brush, apply a small amount of hard solder flux to the area to be tinned.

b. Using a torch or the resistance heating pliers, melt a thin coat of silver solder onto inside of wire grip. See figure 7–10 for use of resistance heating pliers in this operation.

c. Allow terminal to cool in air.

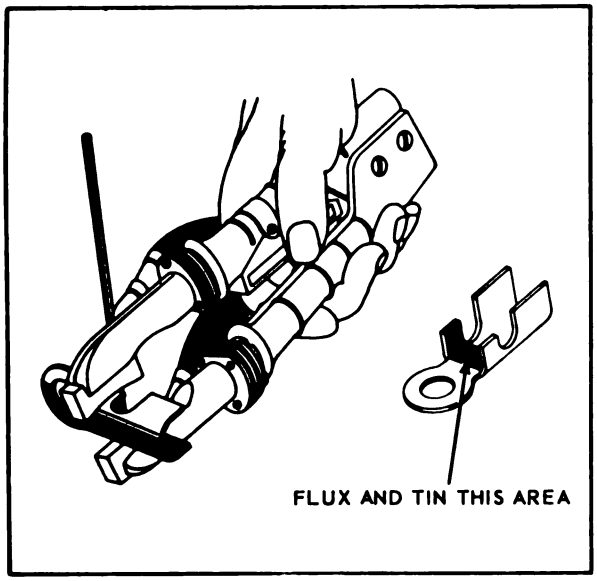


Figure 7–10. Resistance Tinning of Terminal

7–20. PROCEDURE FOR ATTACHING TERMINALS TO THERMOCOUPLE WIRE. Secure terminal to thermocouple wire as follows:

a. Flux previously tinned areas of terminal and wire.

b. Install terminal on wire so that insulation is flush with or protrudes slightly beyond insulation grip. The tinned portion of the conductor should then be inside the wire grip. (See figure 7–11).

c. Crimp wire grip over conductor using modified crimping tool illustrated in figure 7–12.

Note

Do not crimp insulation grip until after soldering operation. The heat of soldering may damage insulation if insulation grip is tight during soldering.

7–21. TORCH SOLDERING TERMINALS TO THERMOCOUPLE WIRE. (See figure 7–11).

a. Use copper shield to protect insulation.

b. Heat joint until flux bubbles and then apply silver solder wire to joint as shown. Keep flame in motion to assure uniform heating.

c. When solder has flowed down into wire grip, remove flame and allow joint to cool without disturbing it. Note that AN 5539 terminals require reinforcement with silver solder at indicated areas. See figure 7–13.

CAUTION

Do not allow solder to flow onto ring tongue as this will prevent proper assembly into system.

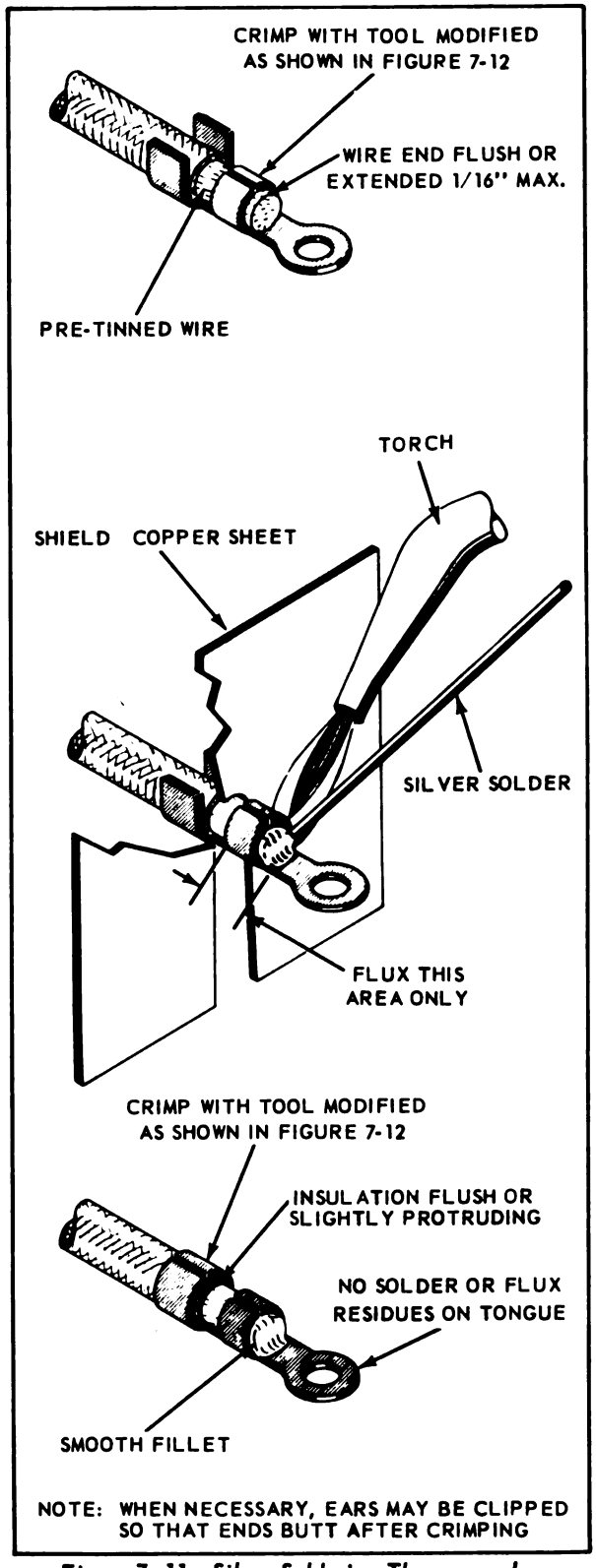


Figure 7–11. Silver Soldering Thermocouple Wire to Terminal

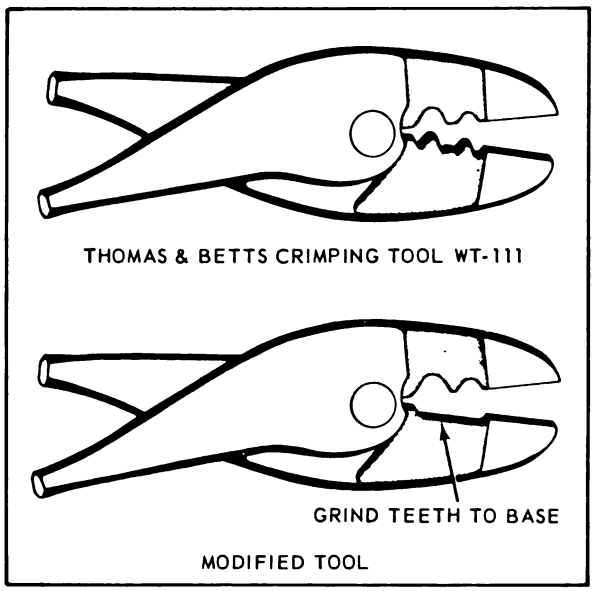


Figure 7–12. Modified Crimping Tool for Thermocouple Terminals

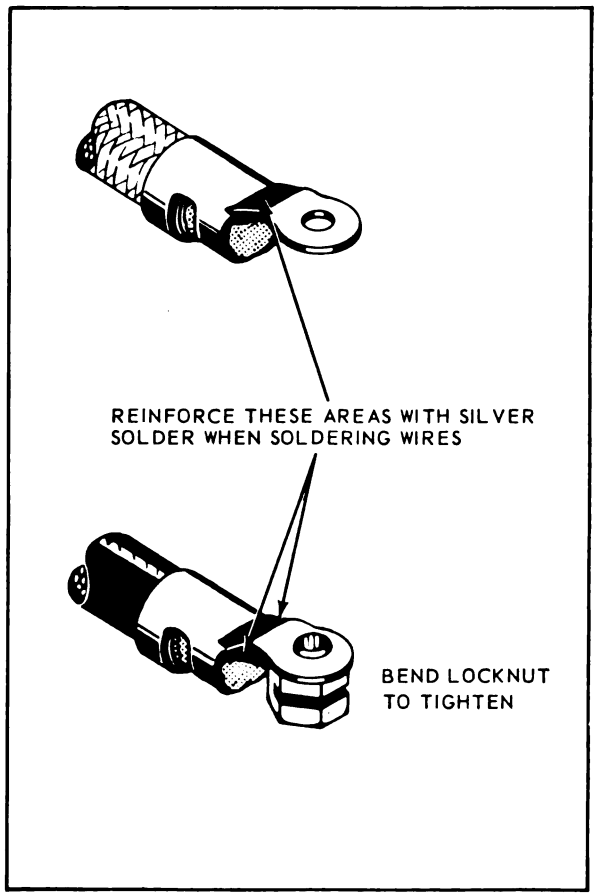


Figure 7–13. Reinforcing Solder on AN 5539 Terminals

7–22. RESISTANCE SOLDERING TERMINALS TO THERMOCOUPLE WIRE.

a. Grasp terminal and wire assembly, prepared in accordance with 7–20, at wire grip area. The resistance heating pliers are to be in the position shown in figure 7–10.

b. Apply current until flux bubbles then apply silver solder wire to connection from conductor end of assembly.

c. Contine to apply heat and watch for flow of solder inside wire grip. When solder is visible at opposite end of wire grip from where it was applied, turn off current.

d. Allow assembly to solidify before removing from pliers.

7–23. CLEANING AND COMPLETING SILVER SOLDERED TERMINAL CONNECTIONS. After the silver solder has solidified and cooled, the junction must be completed as follows:

a. Remove flux residues with warm water and a bristle brush, and then dry thoroughly.

b. Secure insulation grip on insulation using modified crimping tool shown in figure 7–12. The final result is shown in figure 7–11.

Note

Insulation grip ears may be trimmed so they butt.

c. Examine junction to be sure that silver solder has alloyed to wire and terminal. Examine also to be sure that insulation has not been scorched. Rework any connection that is defective.

d. Coat areas indicated in figure 7–14 with zinc chromate brushing compound.

e. Serve the completed extension lead at branching point as described in 7–24, and shown in figure 7–14.

7–24. SERVING THERMOCOUPLE WIRE. After soldering operation has been completed, and solder has cooled, serve thermocouples at the branching point as shown in figure 7–14. Use nylon or waxed cotton cord in cool areas, and fiberglass cord in hot areas. Coat the serving with clear lacquer. The serving will prevent unraveling of the outer jacket.

7–25. SOFT SOLDERING THERMOCOUPLE WIRE.

7–26. TINNING WIRE FOR SOFT SOLDERING. Tin thermocouple wire for soft soldering in the same manner as copper wire as described in section II, paragraphs 2–49 through 2–55. Either dip tinning or soldering iron tinning is satisfactory. Occasionally, if wires are oxidized, rosin-alcohol flux may not do a satisfactory job of tinning; if this happens use the following:

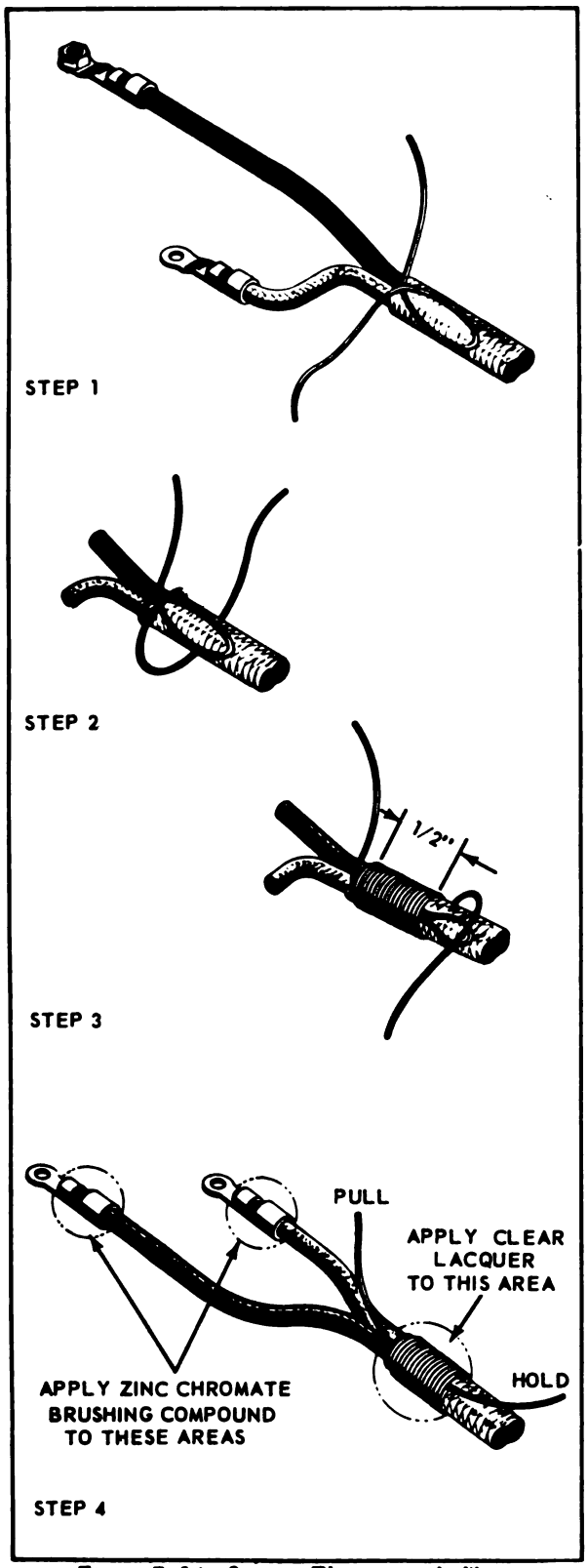


Figure 7–14. Serving Thermocouple Wire

Lactic acid-glycerin-rosin mixture made by mixing (by weight) one part of lactic acid (C. P.) with one part glycerin (U.S.P.), and adding three parts pure, freshly powdered rosin.

Note

When Soldering-iron method is used, use a soldering iron of 200 to 250 watts capacity for tinning thermocouple wires.

7–27. TINNING TERMINALS FOR SOFT SOLDERING. Tin terminal section inside wire grip, using a 200 to 250 watt soldering iron, and rosin core solder. Do not allow flux or solder to get on the insulation grip or on the ring part of the tongue.

Note

Terminals for use with soft solder should be cadmium plated.

7–28. PROCEDURE FOR SOFT-SOLDERING WIRE TO TERMINALS.

a. Install terminals on thermocouple wires as described in 7–20, and illustrated in figure 7–11.

b. Soft solder, using 200 to 250 watt iron and rosin core solder. Make sure that solder flows inside wire grip and forms a smooth fillet.

CAUTION

For soft-soldering, do not use any flux other than rosin-alcohol, regardless of flux used for tinning.

c. Remove excess flux by scrubbing with brush and denatured alcohol.

d. Bend insulation grip ears around insulation using modified crimping tool shown in figure 7–12. Trim ears so they butt flush around small wires. See figure 7–11.

e. Coat areas indicated in figure 7–14 with zinc chromate brushing compound.

7–29. PROCEDURE FOR SOLDERING WIRE TO MS CONNECTORS. Thermocouple contacts in MS series connectors are not tinned by the manufacturer. Therefore it is necessary to properly tin these contacts with soft solder before thermocouple wire is soft soldered into place. MS connector contacts must be removed from inserts for soldering because of the extra heat needed to raise thermocouple wire to solder temperature. Best results are obtained when electrical resistance heating pliers are used to tin the contact and also for soldering wire into contact. The procedure for tinning and soldering is as follows:

a. Tin contact by use of resistance heating pliers or torch. Use rosin-alcohol flux and 60/40 tin-lead

solder or, if necessary use flux described in 7–26, with the same 60/40 tin-lead solder.

b. Remove flux residues. Rosin residues are removed by brushing vigorously with Stoddard's solvent or with denatured alcohol. Lactic acid flux is removed by brushing in warm water. Dry each tinned contact thoroughly before proceeding with next step.

c. Check contact coding and wire coding carefully to avoid mismatch of materials. See tables 7–1 and 7–3.

CAUTION

It is important that thermocouple materials match. Make sure that the thermocouple wire is soldered to a contact of the same material.

d. Insert properly pretinned wire into contact and solder using resistance pliers or torch. Use only rosin core solder for this operation. See figure 7–15.

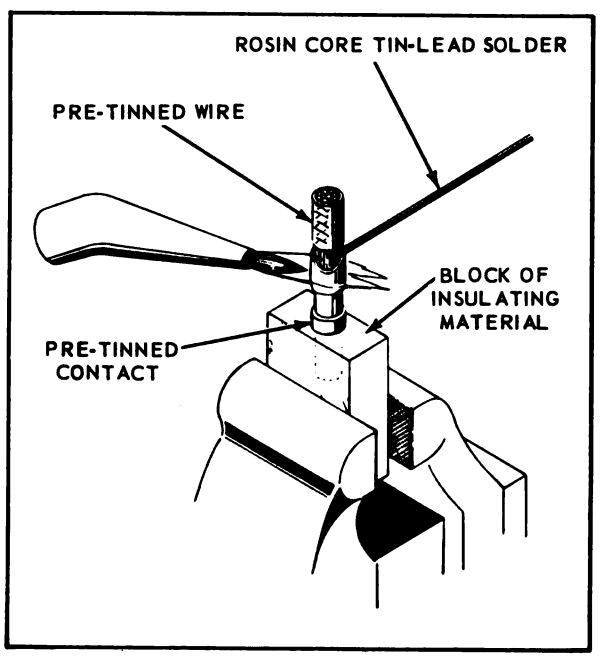


Figure 7–15. Torch Soldering Thermocouple Wire to MS Connector Contact

e. After solder has flowed and alloyed, allow connection to cool without motion. Then remove flux residues with Stoddard's solvent or denatured alcohol.

f. Examine joint to be sure solder has flowed to form smooth fillet, and that no solder is left on outside of solder cup.

g. Reassemble contacts into MS Connector as described in section III, paragraphs 3–57 through 3–73. Be careful to reassembly each contact into the hole from which it was removed.

Note

For chromel and alumel contacts, in addition to visual inspection of the contact stamping, further material verification, separation of contacts during connector assembly, and inspection verification after assembly can be made with the aid of a magnet if desired, as a magnet will attract the alumel contact but not the chromel contact.

7–30. PROCEDURE FOR SOLDERING WIRE TO AN-5537 FIREWALL CONNECTOR. Thermocouple wires are brought through firewalls by means of AN5537 firewall connectors. To preserve the integrity of the system, it is necessary to hard solder wires to the connector on the hot side of the firewall. The cool side of the firewall may be either hard or soft soldered.

CAUTION

Be careful to connect wire leads to mating materials of connector. Connector plugs and sockets are coded with letters to indicate materials. Sizes are also different to aid in quick identification. (See table 7–4 for code).

The procedure for attaching wires is as follows: (See figure 7–3).

a. Disassemble connector as shown. Slide nuts over the pretinned leads which will be installed on the hot side of the firewall.

b. Tin the wire grips of the socket assemblies using hard solder as described in 7–19.

c. Assemble and hard-solder wires to socket assemblies as described in 7–20 through 7–22.

d. Complete assembly of hot side wires by cleaning, crimping insulation grips and coating with zinc chromate brushing compound as described in 7–23.

e. Attach plugs to wires on cold side of firewall by using hard or soft solder as required on applicable drawing for the specific installation. The method of attachment, soldering, cleaning, etc., is the same as that previously described.

7–31. THERMOCOUPLE WIRING INSTALLATION.

7–32. CONNECTING THERMOCOUPLE SPLICES. (See figure 6–16.) Connect thermocouple splices as follows:

a. Slide sleeve over one lead.

b. Bend locknut of lock terminal slightly before assembly to assure tightness.

c. Bring contact areas of two terminals together, and pass screw through plain terminal first and then through locknut of lock terminal.

d. Tighten screw securely.

e. Slide sleeve over terminal and tie securely.

TABLE 7–3

Coding for Thermocouple Contacts in MS Connectors

Manufacturer	Method of Coding	Code			
		Iron	Constantan	Chromel	Alumel
Amphenol	Color	White	Red	Green	Orange
Bendix	Letters	Ir.	Con.	Ch.	Al.
Cannon	Letters	IR	CO	CH	AL

TABLE 7–4

Code for Markings on AN5537

Material	Code	Size
Iron	FE	Large
Constantan	CON	Small
Chromel	CR	Large
Alumel	AL	Small

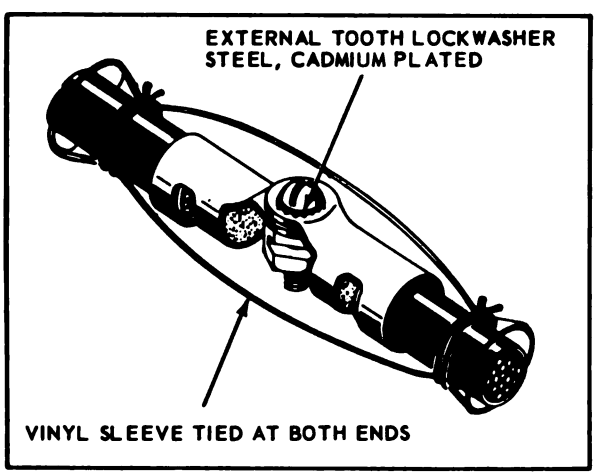


Figure 7–16. Connecting Thermocouple Splices

7–33. MOUNTING AN5537 CONNECTOR ASSEMBLY. AN5537 firewall connector assemblies are mounted as follows: (See figure 7–3).

a. Attach insulating block to firewall on hot side. Bosses on block should fit into holes in firewall so that block face is flush against wall.

b. Push socket assemblies through holes and lock into place with coupling nuts.

c. Push plugs into socket assemblies from cold side of firewall.

7–34. ROUTING THERMOCOUPLE WIRING. Route thermocouple wiring as described generally in section XIV. In addition observe the following special precautions:

a. Support thermocouple wiring so it will not come into contact with heat producing surfaces such as exhaust pipe or combustion chamber at any point.

b. Do not bend thermocouple leads sharply.

c. Do not splice thermocouple leads except where specifically indicated and then only with approved splices such as shown in figure 7–16.

d. Protect adjacent wiring against abrasion from thermocouple splices as described in 7–35.

e. Route thermocouple wiring away from hot spots.

7–35. PROTECTION. Insulate thermocouple spliced terminal connections with sleeves to protect the insulation of adjacent wires from abrasion. Use plastic sleeving in cool areas, and silicone impregnated rubber or glass sleeving in hot areas. Tie sleeving securely at both ends.

CAUTION

Do not use sleeving as a substitute for safe routing.

7–36. SLACK IN THERMOCOUPLE WIRING. (See figure 7–17.) Thermocouple wire installations require the use of fixed wire lengths to maintain a specified resistance. The slack that results should be distributed by one of the following methods:

a. Distribute excess slack evenly between wire supports, as shown in figure 7–17a.

b. If sufficient slack is available, take it up, at a support, in the form of a loop of which the diameter is at least 20 times the thickness of the thermocouple wire, as shown in figure 7–17b.

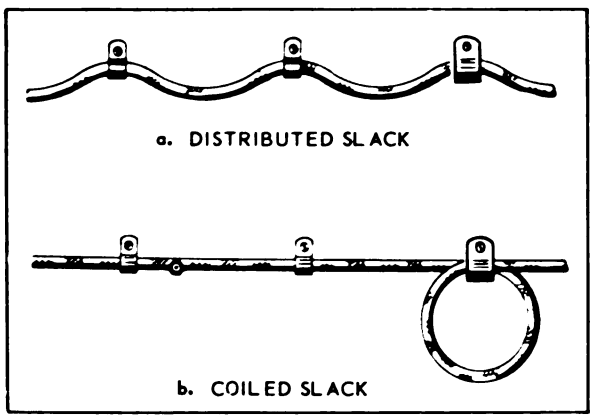


Figure 7-17. Distributing Slack in Thermocouple Wire

CAUTION

Do not bend thermocouple leads to less than a two inch radius. When calibration resistors are used in the circuit to adjust for short lengths, do not allow any excess slack, except for approximately three inches at each end for maintenance.

SECTION VIII

BONDING AND GROUNDING

8–1. INTRODUCTION.

8–2. GENERAL. Bonding and grounding connections are made in aircraft for the following purposes:

a. To protect aircraft and personnel against hazards from lightning discharge.

b. To provide power current return paths.

c. To prevent development of RF potentials.

d. To protect personnel from shock hazard.

e. To provide stability and homogeneity of radio transmission and reception.

f. To prevent accumulation of static charge.

g. To provide fault current return paths.

8–3. SCOPE. This section describes and illustrates the recommended procedures to be followed in the preparation and installation of bonding and grounding connections.

8–4. REFERENCE SPECIFICATIONS.

MIL-M-3171	Magnesium Alloys; Processes for Corrosion Prevention of
MIL-B-5087	Bonding, Electrical, for Aircraft
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-T-6094	Thinner; Dope and Lacquer (Cellulose-nitrate)
MIL-P-6889	Primer, Zinc-Chromate, for Aircraft Use
MS35083	Jumper Assemblies, Bonding and Current Return

8–5. DEFINITIONS.

a. Bonding is the electrical connecting of two or more conducting objects not otherwise adequately connected.

b. Grounding is the electrical connecting of conducting object to primary structure, for return of current.

c. Primary structure is the main frame, fuselage and wing structure of the aircraft (commonly referred to as ground).

8–6. GENERAL PRECAUTIONS AND PROCEDURES. When making bonding or grounding connections in aircraft, observe the following general precautions and procedures:

a. Bond or ground parts to the primary aircraft structure where practicable.

b. Make bonding or grounding connections in such a way as not to weaken any part of the aircraft structure.

c. Bond parts individually wherever possible.

d. Make bonding or grounding connections against smooth, clean surfaces.

e. Install bonding or grounding connections so that vibration, expansion or contraction, or relative movement incident to normal service use will not break or loosen the connection.

f. Locate bonding and grounding connections in protected areas whenever possible; locate connections whenever possible near hand holes, inspection doors or other accessible areas to permit easy inspection and replacement.

g. Do not compression-fasten bonding or grounding connections through any non-metallic material.

8–7. SELECTION OF HARDWARE. Hardware used to make bonding or grounding connections is selected on the basis of mechanical strength, current to be carried and ease of installation. Where connection is made by aluminum or copper jumpers to structure of dissimilar material, a washer of suitable material is installed between the dissimilar matals so that any corrosion which may occur will occur in the washer, which is expendable, rather than in the structure, which is not expendable.

Note

When repairing or replacing existing bonding or grounding connections, be sure to use the same type of hardware as in the original connection. Do not make any changes.

8–8. HARDWARE MATERIAL AND FINISH. Select hardware material and finish from tables 8–1, 8–2 or 8–3, depending on material of structure to which attachment is made, and material of jumper and terminal specified for the bonding or grounding connection.

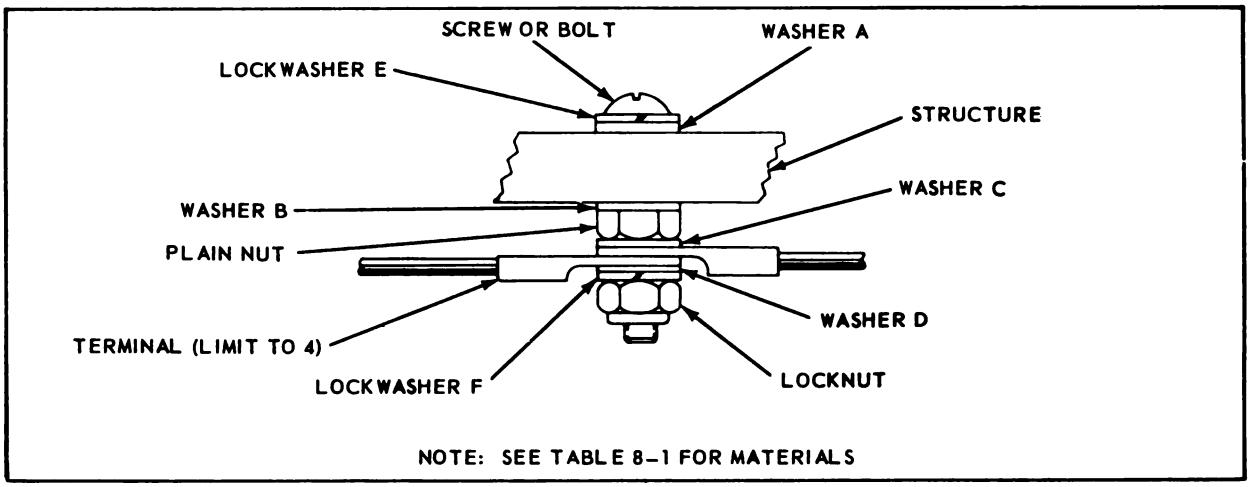


Figure 8-1. Stud Bonding or Grounding to Flat Surface

TABLE 8-1

Hardware for Stud Bonding or Grounding to Flat Surface

(Refer to figure 8-1)

Structure	Screw or Bolt; Lock-Nut	Plain Nut	Washer A	Washer B	Washer C&D	Lock-Washer E	Lock-Washer F
Aluminum Terminal and Jumper							
Aluminum Alloys	Cad. Plated Steel	Tin Plated Brass	Aluminum Alloy	Aluminum Alloy	Cad. Plated Steel or Aluminum	Cad. Plated Steel	Cad. Plated Steel
Magnesium Alloys	Cad. Plated Steel	Cad. Plated Steel	Magnesium Alloy	Magnesium Alloy	Cad. Plated Steel or Aluminum	Cad. Plated Steel	Cad. Plated Steel
Steel, Cadmium Plated	Cad. Plated Steel	Cad. Plated Steel	None	None	Cad. Plated Steel or Aluminum	Cad. Plated Steel	Cad. Plated Steel
Steel, Corrosion Resisting	Corrosion Resisting Steel	Cad. Plated Steel	None	None	Cad. Plated Steel or Aluminum	Cor. Resist. Steel	Cad. Plated Steel
Tinned Copper Terminal and Jumper							
Aluminum Alloys	Cad. Plated Steel	Cad. Plated Steel	Aluminum Alloy	Aluminum Alloy	Cad. Plated Steel	Cad. Plated Steel	Cad. Plated Steel or Aluminum
Magnesium Alloys	AVOID CONNECTIONG COPPER TO MAGNESIUM						
Steel, Cadmium Plated	Cad. Plated Steel	Cad. Plated Steel	None	None	Cad. Plated Steel	Cad. Plated Steel	Cad. Plated Steel
Steel, Corrosion Resisting	Corrosion Resisting Steel	Cor. Res. Steel	None	None	Cad. Plated Steel	Cor. Resist. Steel	Cor. Resist. Steel

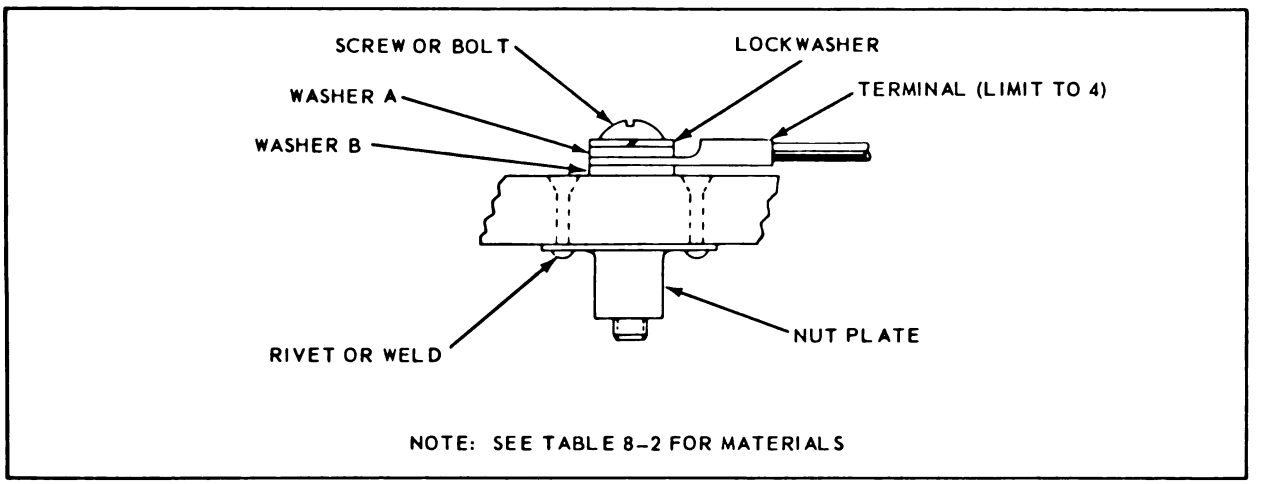


Figure 8-2. Plate Nut Bonding or Grounding to Flat Surface

TABLE 8-2

Hardware for Plate Nut Bonding or Grounding To Flat Surface
(Refer to Figure 8-2)

Structure	Screw or Bolt; Nut Plate	Rivet	Lock Washer	Washer A	Washer B
Aluminum Terminal and Jumper					
Aluminum Alloys	Cad. Plated Steel	Alum. Alloy	Cadmium Plated Steel	Cad. Plated steel or aluminum	None
Magnesium Alloys	Cad. Plated Steel	Alum. Alloy	Cadmium Plated Steel	Cad. Plated steel or aluminum	None or Mag. Alloy
Steel, Cadmium plated	Cad. Plated Steel	Cor. Res. Steel	Cadmium Plated Steel	Cad. Plated Steel or aluminum	None
Steel, Corrosion Resisting	Corrosion Resist. Steel or Cad. Plated Steel	Cor. Res. Steel	Cadmium Plated steel	Cad. Plated Steel or aluminum	Cad. plated steel
Tinned Copper Terminal and Jumper					
Aluminum Alloys	Cad. Plated Steel	Alum. Alloy	Cadmium Plated Steel	Cad. Plated Steel	Alum. Alloy
Magnesium Alloys	AVOID CONNECTING COPPER TO MAGNESIUM				
Steel, Cadmium plated	Cad. Plated Steel	Cor. Res. Steel	Cadmium Plated Steel	Cad. Plated steel	None
Steel, Corrosion Resisting	Corrosion Resist. Steel	Cor. Res. Steel	Cadmium Plated Steel	Cad. Plated Steel	None

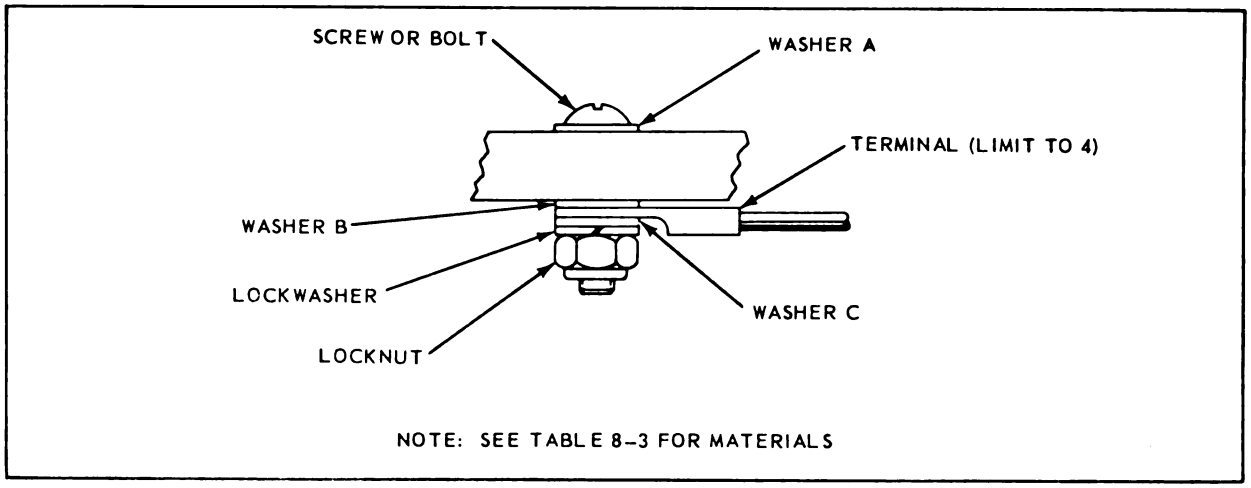


Figure 8-3. Bolt and Nut Bonding or Grounding to Flat Surface

TABLE 8-3

Hardware for Bolt and Nut Bonding or Grounding to Flat Surface
(Refer to Figure 8-3)

Structure	Screw or Bolt; Lock Nut	Lock Washer	Washer A	Washer B	Washer C
Aluminum Terminal and Jumper					
Aluminum Alloy	Cad. Plated Steel	Cad. Plated Steel	Cad. Plated Steel or aluminum	None	Cad. Plated Steel or aluminum
Magnesium Alloy	Cad. Plated Steel	Cad. Plated Steel	Magnesium Alloy	None or Mag. Alloy	Cad. Plated Steel or aluminum
Steel, Cadmium Plated	Cad. Plated Steel	Cad. Plated Steel	Cad. Plated Steel	Cad. plated steel	Cad. plated steel or alumium
Steel, Corrosion Resisting	Corrosion Resisting Steel or Cad. plated steel	Cad. Plated Steel	Corrosion Resisting Steel	Cad. plated steel	Cad. plated steel or aluminum
Tinned Copper Terminal and Jumper					
Aluminum Alloy	Cad. plated steel	Cad. Plated Steel	Cad. plated steel	Alum Alloy	Cad. plated steel
Magnesium Alloy	AVOID CONNECTING COPPER TO MAGNESIUM				
Steel, Cadmium Plated	Cad. plated steel	Cad. Plated steel	Cad. plated steel	None	Cad. plated steel
Steel, Corrosion Resisting	Corrosion Resisting Steel or Cad. Plated Steel	Cad. Plated steel	Corrosion Resisting Steel	None	Cad. plated steel

8–9. SELECTION OF STUD. Use either an AN screw or bolt of the proper size for the specified jumper terminal. Length of screw or bolt should be such that when bonding or grounding connection is fully tightened approximately 1/8 inch of screw protrudes beyond top of nut.

8–10. SELECTION OF NUTS. Use AN nuts, either plain or self-locking where indicated in figures 8–1 and 8–3. Use an all-metal self-locking nut if practicable. Always use an all-metal self-locking nut where current is, or will be present. Where installation conditions require, use an AN nut-plate, riveted to structure.

8–11. SELECTION OF WASHERS. Use AN plain washers and split lockwashers where indicated in figures 8–1, 8–2, 8–3. Always use split lockwashers with nuts, either plain or self-locking. With aluminum terminals use a plain washer of at least the diameter of the terminal tongue, next to the aluminum terminal. If an AN washer does not meet this requirement, use a washer of the SAE heavy series, or a special washer made for this application

8–12. SELECTION OF CABLE CLAMP. For bonding or grounding to cylindrical surfaces use an AN735 clamp. Where an AN735 clamp is not available, or where installation conditions do not allow its use, an uncushioned AN742 clamp may be substituted.

CAUTION

Do not use cushioned clamps in any bonding or grounding connection.

8–13. PREPARATION OF BONDING OR GROUNDING SURFACES. Clean bonding and grounding surfaces thoroughly before making the connection. Remove all oil, grease, paint, anodic film or other non-conducting material from an area slightly larger than the connection.

CAUTION

Do not use abrasives such as emery cloth, crocus cloth, steel wool, etc. These may leave particles imbedded in the surface or scattered in the area which may cause corrosive action.

8–14. CLEANING PROCEDURE FOR ALUMINUM SURFACES. Apply a coating of petrolatum compound to bonding or grounding surface of aluminum structure, and clean surface thoroughly, using steel wire brush with pilot as shown in figure 8–4. Wipe off the petrolatum compound with a clean dry cloth.

8–15. CLEANING PROCEDURE FOR MAGNESIUM ALLOY SURFACES. Prepare magnesium alloy surfaces for bonding or grounding as follows:

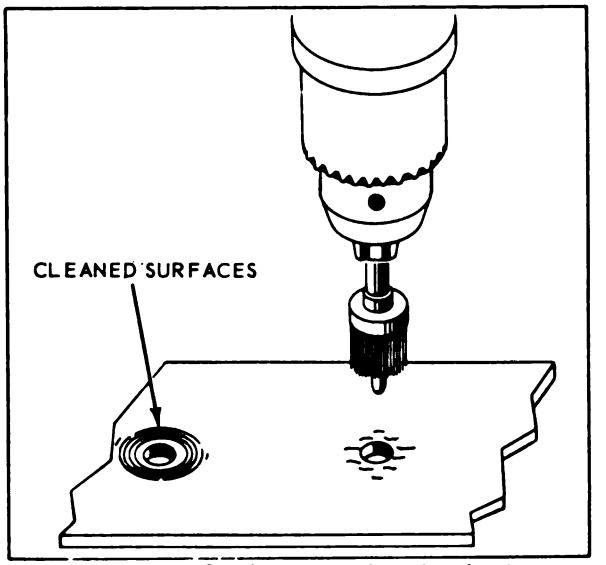


Figure 8–4. Steel Wire Brush With Pilot for Cleaning Aluminum Surfaces

a. Remove grease and oil from surface with stoddard's solvent.

b. Remove paint or lacquer, if present, from surface with lacquer thinner (Military Specification MIL-T-6094).

c. Brush area liberally with chrome pickle solution (Military Specification MIL-M ,,71) for one minute, then rinse within five seconds by brushing with clean water.

d. Dry thoroughly.

8–16. CLEANING PROCEDURE FOR STEEL SURFACES. When the surface is corrosion-resisting or plated steel, clean bonding or grounding surface as described in 8–15, steps a and b.

CAUTION

Do not remove zinc or cadmium plate from steel surfaces.

8–17. METHODS OF BONDING OR GROUNDING. Bonding or grounding connections are made directly to a flat surface of basic structure, or to a cylindrical surface of basic structure,

8–18. CONNECTION TO FLAT SURFACES. Bonding and grounding connections are made to flat surfaces by means of through bolts or screws where installation has easy access. There are three types of bolted connection as follows:

a. Stud connection: (See figure 8–1 and table 8–1) In this type of connection a bolt or screw is locked securely to structure, thus becoming in effect a stud. Grounding or bonding jumpers can be removed or added to the shank of stud without removing stud from structure.

b. Nut plate and bolt connection: (See figure 8–2 and table 8–2) Nut plates are used where access to the nut for repairs may be difficult. Nut plates are riveted or welded to a clean area of the structure. Cleaning of structure is done in accordance with 8–14 through 8–16 as applicable.

c. Nut and bolt connection: (See figure 8–3 and table 8–3) In this connection the bolt or screw is not attached permanently to structure. When jumpers are to be added or removed, the entire connection is remade.

The table under each figure lists materials and platings which are compatible with the structure to which they are mounted. These materails are selected so that corrosion, if it occurs, will occurs in the washers, which are expendable, rather than in the structure which is not expendable.

8–19. CONNECTION TO TAB RIVETED TO STRUCTURE. For bonding leads carrying high current, size AN-4 or larger, do not make the connection directly to the structure, but to a tab of suitable size adequately bonded to the aircraft structure. (See figure 8–5.) When a bonding or grounding connection is made to a tab riveted to structure rather than directly to structure, clean the bonding or grounding surface and make the connection.

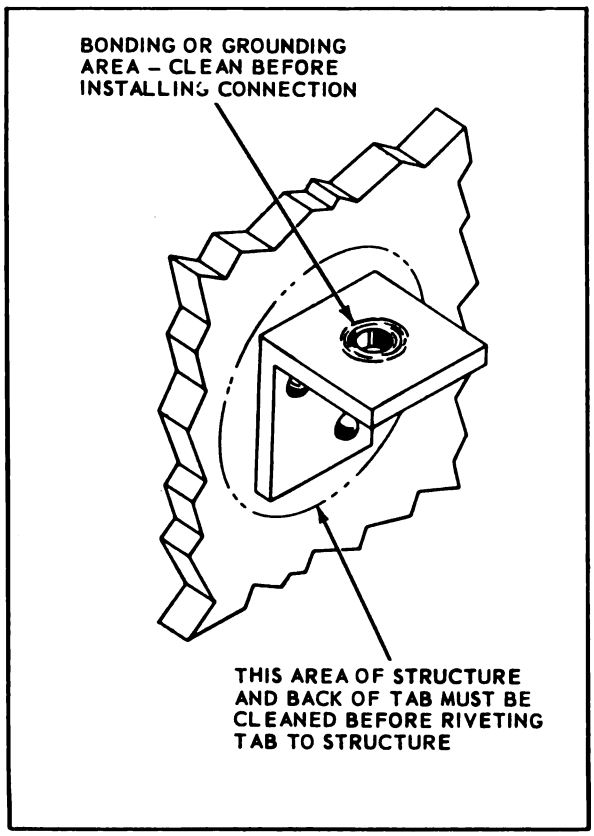


Figure 8–5. Bonding Tab Riveted to Structure

exactly as though the connection were being made to structure. If it is necessary to remove the tab for any reason, replace rivets with one size larger. Make sure mating surfaces of structure and tab are clean, and free of anodic film.

8–20. CONNECTION TO CYLINDRICAL SURFACES. Make bonding or grounding connections to aluminum alloy, magnesium alloy or corrosion resisting steel tubular structure as shown in figures 8–6 and 8–7. Figure 8–6 shown the arrangement of hardware for bonding with an aluminum jumper. Because of the ease with which aluminum is deformed, it is necessary to distribute screw and nut pressure by means of plain washers as shown. Figure 8–7 shows the arrangement of hardware for bonding with a copper jumper. No extra washers are used. If installation conditions require use AN742 clamp (uncushioned) instead of AN735. Do not change any other hardware if this substitution is made.

8–21. BONDING CONDUIT TO STRUCTURE. See figure 8–8. Bond aluminum alloy or corrosion-resisting steel conduit to structure as shown in figure 8–8. If installation conditions require, AN742 clamp may be used instead of AN735, using same hardware.

8–22. TIGHTNESS OF CONNECTIONS. Make sure that all connections are tight as evidenced by the split lock-washers being completely compressed.

CAUTION

When terminal is under head of screw or bolt (as shown in figure 8–2), it is preferable not to install more than one terminal. A loose screw with two terminals may cause inadvertent operation of equipment.

8–23. BONDING AND GROUNDING JUMPERS. To accomplish the purpose of bonding or grounding, it is necessary to provide a conductive path where direct electrical contact does not exist. Jumpers are used for this purpose in such applications as between moving parts, between shock-mounted equipment and structure, and between electrically conducting objects and structure. Keep jumpers as short as possible; if practical under three inches. Do not use two or more jumpers in series.

8–24. FABRICATING BONDING AND GROUNDING JUMPERS. Jumpers of tinned copper wire are fabricated in accordance with Military Standard Drawing MS25083. For smaller size wire, terminate with MS25036 insulated copper terminal lugs of appropriate size. Use standard tool MS25037 for crimping terminals to wire. For larger wire size, terminate with MS20659 uninsulated copper terminal lugs, crimped to the wire with AN3427 tool. Jumpers may also be facricated of 1/16 inch ID #36 gage copper braid, using MS25036 terminal lugs. Instructions for use of crimping tools are given in section V.

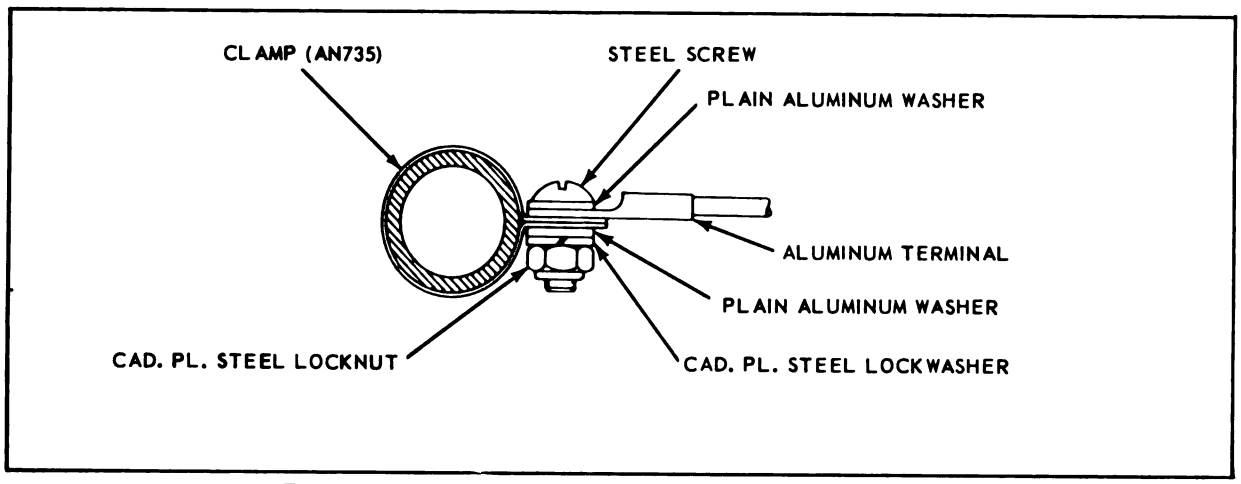


Figure 8–6. Aluminum Jumper Connection to Tubular Structure

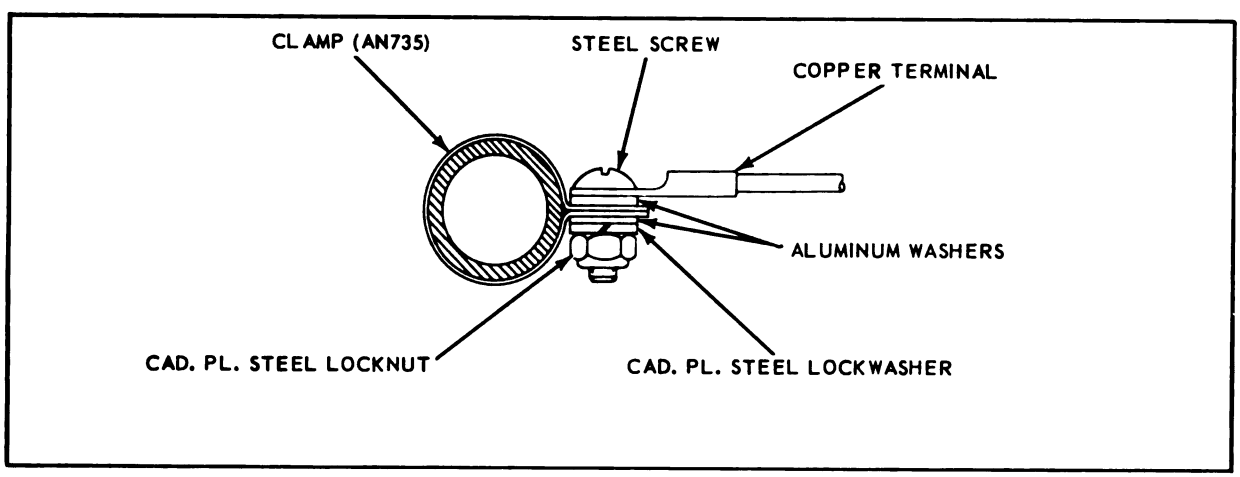


Figure 8–7. Copper Jumper Connection to Tubular Structure

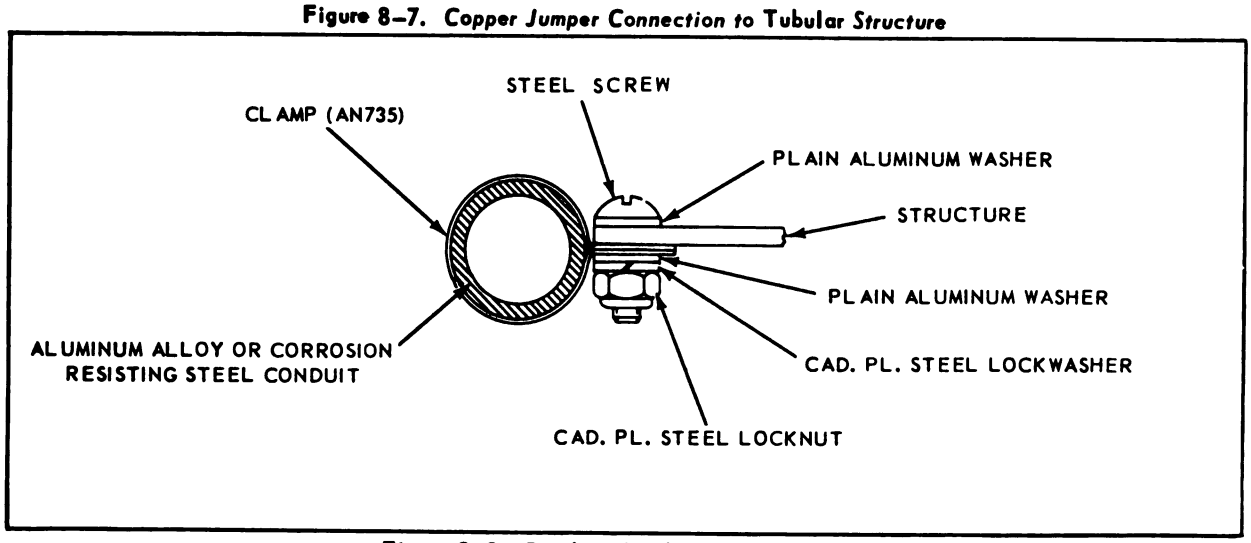


Figure 8–8. Bonding Conduit to Structure

8–25. QUICK-DISCONNECT JUMPERS. Where a quick-disconnect jumper is required, crimp an AN753 electrical disconnect splice into a copper wire jumper, fabricated as described in 8–24, using the standard tool MS25037. Note that the disconnect splice is not centered in the jumper; but is installed so that the coupler remains on the short end when thd jumper is disconnected.

8–26. TESTING BONDS AND GROUNDS.

8–27. RESISTANCE TESTS AFTER CONNECTION. The resistance across a bonding or grounding jumper is required to be 0.1 ohms or less. Tests are made after the mechanical connection is completed, and consists of a multiohmmeter reading of the overall resistance between the cleaned areas of the object and the structure. See figure 8–9.

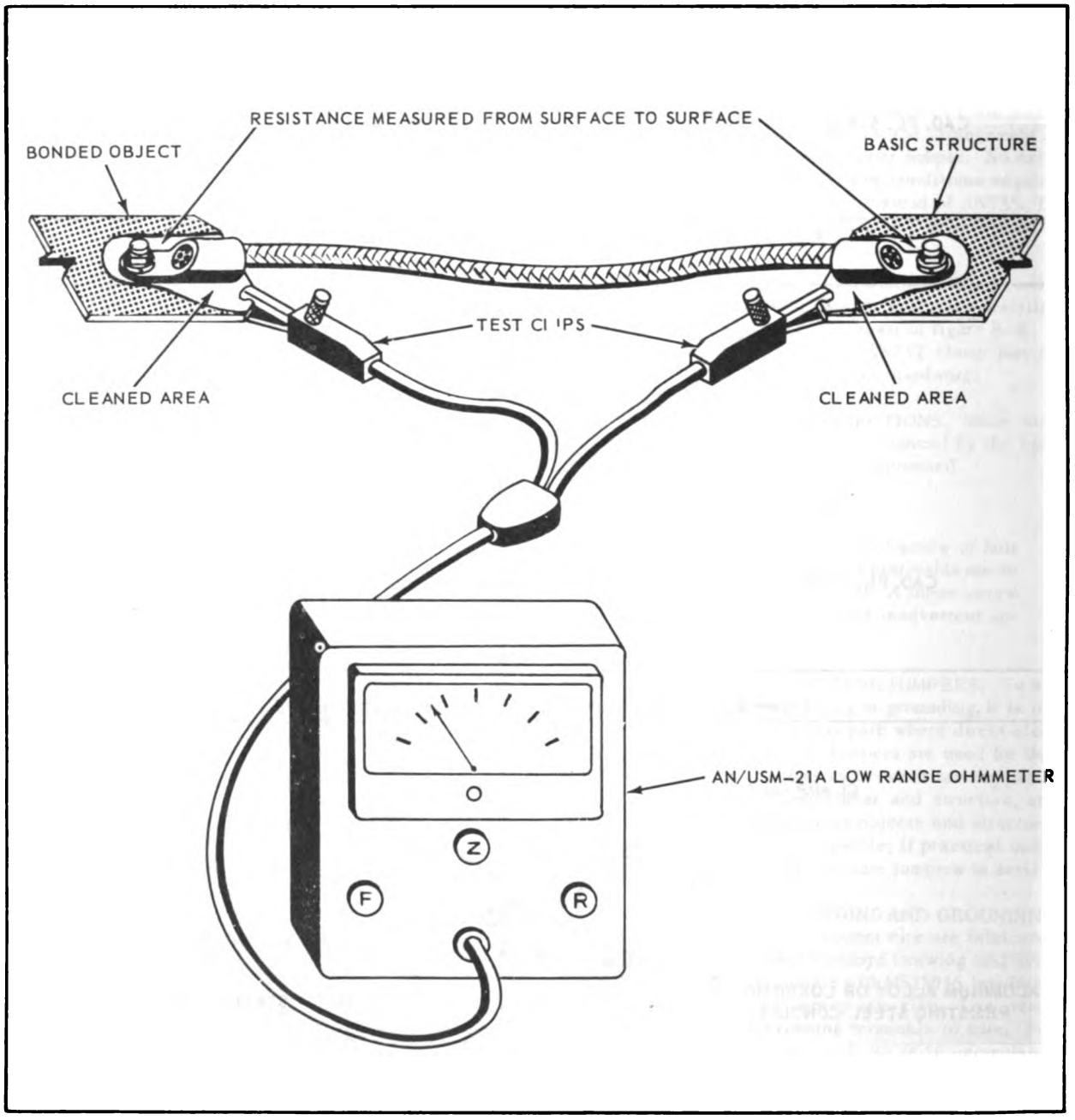


Figure 8–9. Special Milliohmmeter and Clip Leads for Testing Bond Resistance

8–28. RESISTANCE TEST PROCEDURE. Measurements of the specified resistance value are made with a special calibrated low-range ohmmeter such as the AN/USM-21A. Proceed as follows, observing the precautions emphasized in the meter instruction manual.

a. With the Function Control OFF, set the Range Control to the 0.1 ohms position.

b. Attach the instrument test-clips for intimate contact with the cleaned areas immediately adjacent to the jumper terminal lugs of object and structure.

c. Set the Function Control to CALIBRATE, then use the Calibration Adjustment Control to obtain a 0.1 ohm full scale deflection.

d. Set the Function Control to OHMS position, and note the bond (only) reading. It should be less than 0.1 ohm.

e. Return the spring loaded Function Control to OFF position, and remove the test-clip leads and instrument.

f. If the specified resistance value has been obtained, the cleaned areas are now ready for refinishing.

8–29. REFINISHING.

8–30. REFINISHING ALUMINUM ALLOY SURFACES. Within one week after any area has been cleaned and connection made, refinish aluminum surfaces as follows:

a. Apply coat of zinc chromate brushing compound, and allow to dry.

b. When thoroughly dried, refinish cleaned area to match original surrounding finish.

8–31. REFINISHING MAGNESIUM ALLOY SURFACES. Within 24 hours after cleaning surface of magnesium alloys, apply a protective coat of zinc chromate brushing compound. Within one week after making and testing the connection, refinish cleaned area to match original surrounding finish.

8–32. REFINISHING STEEL SURFACES. Within one week after connection has been made, refinish cleaned area to match original surrounding finish.

SECTION IX

SOLDERING

9-1. INTRODUCTION.

9-2. GENERAL. Soldered connections are used in aircraft electrical wiring to form a continuous and permanent metallic connection having a constant electrical value. The importance of establishing and maintaining a high standard of workmanship for soldering operations cannont be over-emphasized.

9-3. SCOPE. This section describes the materials and equipment used in soldering aircraft interconnecting wiring. It also describes and illustrates preparation and care of equipment, procedures to be followed and the soldering techniques necessary to make a good soldered joint.

9-4. In addition, special materials, equipment and techniques used in soldering printed circuit assemblies are described where they differ from those used in general electrical soldering. In the repair of printed circuit assemblies, soldering is closely associated with repairs to the insulating base and conductor pattern, and with replacement of components. Therefore, typical procedures and techniques for making such repairs are included in this section.

9-5. REFERENCE SPECIFICATIONS AND STANDARDS.

O-F-499	Flux, Brazing, Silver Alloy, Low Melting Point
QQ-S-561	Solder, Silver
QQ-S-571	Solder, Soft, (Lead-Alloy, Tin-Lead Alloy and Tin Alloy)
LLL-R-626	Rosin, Gum; Rosin, Wood; Rosin, Tall Oil
MIL-A-6091	Alcohol, Ethyl, Specially Denatured, Aircraft
MIL-S-6872	Soldering Process, General Specification For
MIL-D-6998	Dichloromethane, Technical
MIL-F-20329	Flux, Soldering, Rosin Base, General Purpose
MIL STD 429	Printed Circuit Terms and Definitions

9-6. DEFINITIONS AND DESCRIPTIONS.

9-7. SOLDERING. Soldering is the process of joining two (or more) metals together at a temperature lower than the melting points of the metals. In its molten state, solder chemically dissolves part of the metal surfaces to be joined. However, most metals exposed to the atmosphere acquire a thin film of tarnish or oxide; the longer the exposure the thicker the film will become. This film is present, even though it is not visible, and solder alone cannot dissolve it. A soldering flux with a melting point lower than the solder must be used to "wet" the metal and allow the solder to penetrate it and remove the film. The flux melts first, removing the tarnish or metallic oxide, and also preventing further oxide from forming while the metal is being heated to soldering temperature. The solder then melts, floating the lighter flux and the impurities suspended in it to the outer surface and edges of the molten fillet. The solder cools and forms an alloy with the metal. Most of the flux is burned away during the soldering process; any residue is removed by appropriate cleaning methods.

9-8. The soldering methods used for general aircraft wiring are essentially the same for both production soldering and for repair work. For printed circuit assemblies, production methods and repair methods are different. In production, a dip soldering method is used, where several connections are made at the same time. Soldering repairs, however, are made individually using techniques similar to those used for soldering general wiring, with special precautions to prevent thermal damage to the heat-sensitive, closely packed circuit elements.

9-9. SOFT SOLDER. Soft solder is an alloy consisting of various combinations of tin and lead with silver and other additives, which melts at temperatures below 700 degrees F. It may be in bar form to be melted for tinning, or in the form of rosin-cored solder for use with a soldering iron or other heating means.

9-10. Soft solder used in aircraft electrical wiring conforms to the requirements of Federal Specification QQ-S-571. For general applications at low temperatures (up to 248 degrees F max.) use Composition Sn60 (60% tin, 40% lead) to solder tin-coated copper wire and coaxial cable. For silver-coated copper wire in high temperature applications (up to 375 degrees F max.) use a lead-silver mixture, Composition Ag 2.5 or Ag 5.5. Do not confuse high temperature soft solder with the hard solder described in 9-11. For soldering printed circuit boards use a eutectic solder (63% tin, 37% lead) with a silver additive of one to three percent. Rosin-cored solder, tublar type, 1/32 inch diameter is recommended for printed circuits.

9–11. HARD SOLDER. Hard solder, often called brazing alloy, is a silver alloy, Federal Specification QQ-S-561, which melts at temperatures ranging from 700 to 1600 degrees F. Hard solder is used when greater mechanical strength or exposure to higher temperatures is required. Hard solder is commonly used in the aircraft electrical system for soldering thermocouple connections (refer to Section VII). Hard solder is not used on printed circuits.

9–12. FLUX. Flux is a chemical reducer used for surface conditioning before and during the soldering process. With soft solder, use only water-white rosin, dissolved to a paste-like consistency in denatured alcohol, (Military Specification MIL-F-20329). With hard solder, use borax, or similar material, mixed to a paste with water, (Federal Specification O-F-499). A special solder sometimes used in thermocouple connections is described in Section VII, paragraph 7–26.

9–13. TYPICAL SOLDERING OPERATIONS. Following are examples of typical soft-soldering operations used in aircraft electrical wiring:

Note

Hard-soldering procedures are described in Section VII.

a. Tinning: Wires or cables preparatory to joint soldering and to fuse ends; contact pins and inside purfaces of solder cups; shielded wire braid, after twisting, to fuse, terminate and connect.

b. Soldering: Wires and cables, previously tinned, inserted into solder cups of terminals, or mechanically wrapped on shaped lugs and post or hooked terminals; twisted connections, or broken wire for emergency repair; printed circuit conductor pattern defects, or component leads and lugs to conductor pattern terminal areas.

c. De-soldering: Soldered joints prior to re-making; printed circuit component connections to remove component for replacement.

9–14. HEAT APPLICATION METHODS.

9–15. SOLDERING IRON. The most commonly used method of heat application for soldering joints in aircraft electrical wiring is by means of an electrically heated hand-held soldering iron. In addition to the conventional iron, a pencil iron or a soldering gun are frequently used (see figure 9–1.) Pencil irons except for their smaller size, are identical to conventional irons, and are used for precision soldering of small units and miniature assemblies. Soldering guns, because they heat quickly, are excellent for intermittent use.

9–16. RESISTANCE SOLDERING. See figure 9–2. Resistance soldering is frequently used in large volume production, where the operation is standardized. In this method a low voltage transformer is used and the metal to be soldered is heated by the resistance to a flow of electric current. The work is gripped between two electrodes, completing the circuit and heating the metal for soldering. In another application, a carbon pencil is used as one electrode, and the metal to be soldered forms the other electrode; when contact is established through the carbon pencil intense heat is generated at the point of contact. Resistance soldering is well adapted to the soldering of small parts, or for congested assemblies where it is desired to restrict heat to a small part of the assembly.

9–17. TORCH SOLDERING. Torch soldering is used where a high heat is required, as in silver soldering. This process is also suitable for soft-soldering large work which is not part of an assembly, or when the part to be soldered can be removed for soldering. For example, wires may be torch-soldered to large contacts which habe been removed from MS connectors. Torch soldering is not suitable for soldering small parts.

9–18. DIP-SOLDERING. Dip soldering is the process of immersing connections in molten solder; one or more connections can be made in a single operation. This process is used on printed circuits, where the conductor pattern is one one side of the board, and the components on the opposite side. Joints are mechanically secured, dipped first into liquid flux and then into molten solder.

9–19. PREPARATION AND MAINTENANCE OF SOLDERING IRON. For successful, effective soldering, the soldering iron tip must be tinned to provide a completely metallic surface through which the heat may flow readily from the iron to the metal being soldered. If no tinning is present, the iron will oxidize and the heat cannot flow through. Copper has a very high rate of heat conductivity, but copper tips oxidize quickly, and must be frequently cleaned and re-tinned. If a tip has be come badly burned and pitted as a result of overheating, replace it.

9–20. PREPARING THE SOLDERING IRON. Before using the soldering iron, prepare it as follows:

a. With the iron shut off, file each working surface of the soldering iron tip with a double-cut mill file until it is smooth and of a gright copper color. See figure 9–3. Remove copper fuzz from dressed edges with a file card.

b. Plug in the iron and apply cored solder just as the bright dressed copper color is turning to a pigeon-blue, bronze, oxide color. This will allow the flux to "wet" and clean the working area when the solder melts to form an even bright silver coating on the tip. (See figure 9–4.)

CAUTION

Do not allow the iron to come up to full temperature before starting the tinning operation.

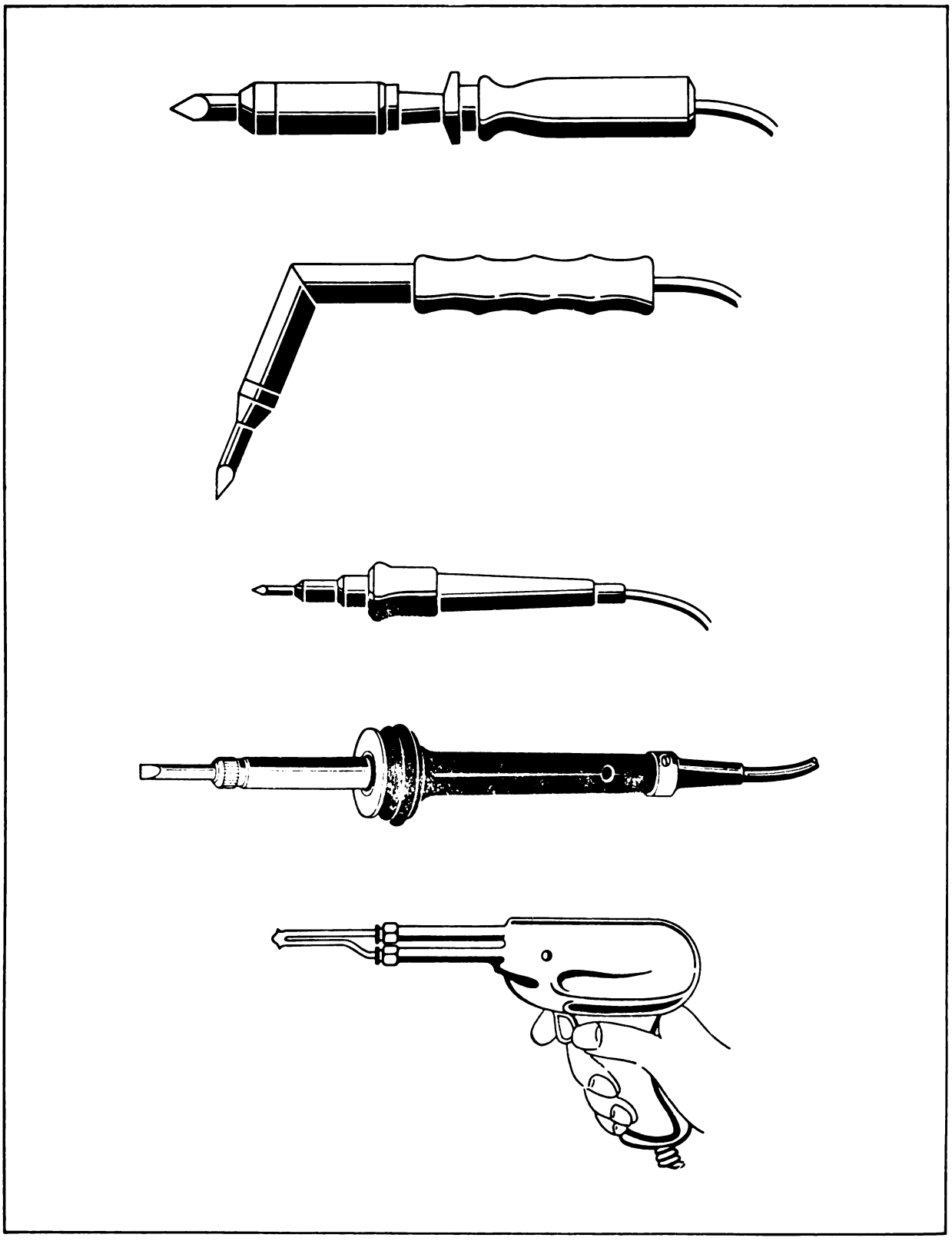


Figure 9–1. Types of Hand Soldering Irons

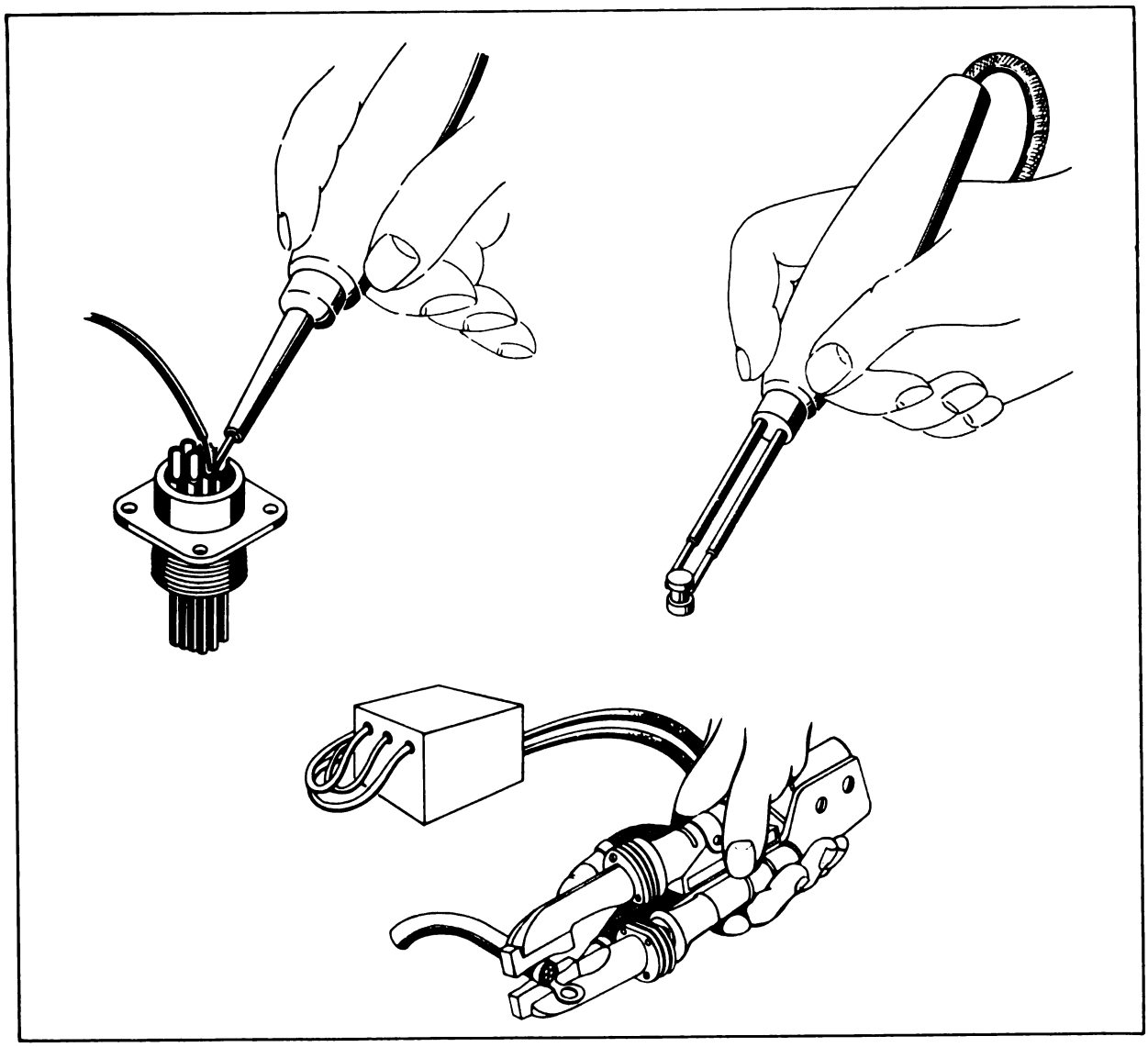


Figure 9–2. Resistance Soldering

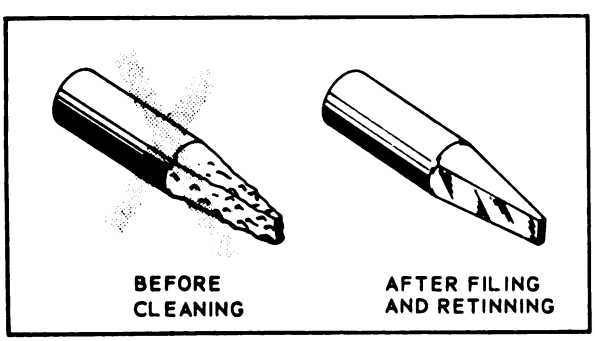


Figure 9–3. Soldering Iron Tip Before and After Cleaning

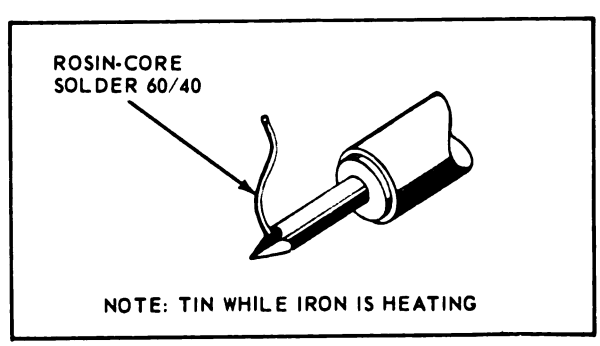


Figure 9–4. Tinning Soldering Iron Tip

c. Wipe off excess solder with a damp sponge or cloth.

9–21. Some copper soldering iron tips used in production soldering are coated with pure iron to help prevent oxidation. Follow manufacturer's instructions for cleaning such irons. A clean damp cloth may be used to wipe the iron.

Note

Do not file soldering iron tips coated with pure iron. Filing will ruin the protective coatting. If the tip is pitted, replace it.

9–22. SOLDERING IRON MAINTENANCE. During use, just before each application, pass the soldering iron tip with a rotary motion through the folds of a damp cleaning sponge, or wipe on an asbestos wiping pad. This will remove the surface dross and excess solder from the working surface.

CAUTION

Never shake or "whip" an iron to get rid of dross or excess solder droplets.

9–23. Once a day remove the tip from the iron and clean out the black scale from the inside of the iron and from the tip with fine steel wool. When the iron or tip is new, coat the inside of the shank with dry flake graphite or anti-seize material to prevent freezing, and to insure maximum heat transfer. When replacing the tip, make sure to insert the tip to the full depth of the casing, seated firmly against the heating element.

9–24. SOLDERING OPERATION - GENERAL PRECAUTIONS AND PROCEDURES. Regardless of the heating method used in the soldering process, a good connection will result only if the proper soldering techniques are followed, and certain precautions observed. The following instructions apply generally to soldering operations. Some special soldering techniques used in assembling or repairing printed circuit boards are listed in 9–51 and 9–52. Detailed procedures are given for soldering wires to MS connectors in section III, to coaxial connectors in section IV and for thermocouple connections in section VII.

Note

A quality soldered joint can be accomplished only on a mechanical connection of approved geometry, dress and dimensions.

9–25. CLEANLINESS. Cleanliness is of the utmost importance in the soldering operation. If possible, soldering should be done in an area that is reasonably clean and free from excessive dust. Drafty areas should be avoided so that the soldering iron will not cool. Parts contaminated with dirt, oil, grime, grease, etc. cannot be sucessfully soldered. Make sure that the parts are mechanically "bright-clean", before soldering. Clean the parts with a cloth or brush dipped in alcohol, carbon tetrachloride, trichlorethylene or other approved solvent. Badly corroded parts may be cleaned carefully by mechanical means such as fine abrasive paper, a wire brush or by careful scraping with a knife blade.

9–26. PRE-TINNING. Wires to be attached to most electrical connectors must be pre-tinned. Follow the instructions given in Section II, paragraphs 2–48 through 2–55.

9–27. SELECTION OF FLUX AND SOLDER. Use only the solder and fluxes described in 9–9 through 9–12.

CAUTION

Do not use any corrosive flux in aircraft electrical wiring.

9–28. HEATING CAPACITY. Use a soldering iron or other heating method of sufficient capacity to heat the metal being soldered to solder melting temperature.

9–29. SELECTION OF SOLDERING IRON. The sole purpose of the soldering iron is to heat the joint to a temperature high enough to melt the solder. Select a soldering iron with a thermal capacity high enough so that the heat transfer is fast and effective. An iron with excessive heat capacity will burn or melt wire insulation; an iron with too little heat capacity will make a cold joint in which the solder does not alloy with the work. Soldering irons are available in wattage ranges from 20 to 500 watts. Irons with wattage ratings of 60, 100 and 200 watts are recommended for general use in aircraft electrical wiring. Pencil irons with a rating of 20 to 60 watts are recommended for soldering small parts. The soldering iron recommended for printed circuit soldering is a lightweight 55 watt iron with a 600° F Curie point tip control. This iron has a three-wire cord to eliminate leakage currents which could damage the printed circuits.

9–30. A soldering iron should also be suited to the production rate. Do not select a small pencil iron where a high steady heat flow is required. A soldering gun is useful for intermittent work, but is not suitable for high speed production work because of the warm-up time required each time the trigger is depressed.

9–31. CHOICE OF SOLDERING TIP. Select the tip best suited for the size and shape of the work being soldered. Some common tip shapes are shown in figure 9–5. Soldering iron tips are available in sizes from 1/16 inch to 2 inches in diameter. For general use a tip of 1/4 inch to 3/8 inch diameter is recommended. For printed circuit soldering use a long shank tip of 1/16, 1/8, 3/32 or 3/16 inch diameter; screwdriver, chisel and pyramid shapes are recommended.

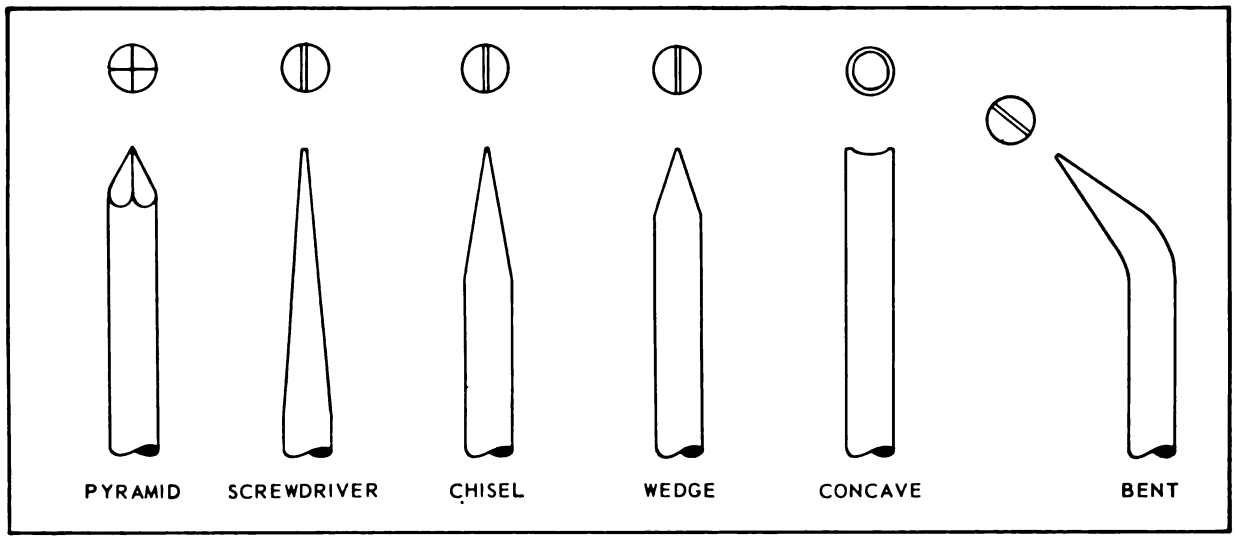


Figure 9–5. Soldering Iron Tip Shapes

9–32. SOLDERING IRON. Before starting the soldering operation, make sure that the iron tip is clean, smooth and well-tinned. See 9–19 through 9–23 for instructions on preparation and maintenance of soldering iron. When resistance soldering equipment is to be used make sure that probes are clean.

9–33. SECURING THE JOINT. Whenever possible make sure that the joint is mechanicaliy secure before soldering. When this is not possible, as with MS connector contacts, make sure that the joint is held rigid during the cooling period.

9–34. APPLICATION OF HEAT AND SOLDER. Apply flux-core solder at the exact point between the metal and the soldering iron, as shown in figure 9–6 and hold the iron directly against the assembly. Melt the solder on the joint, not on the iron. Place the soldering iron firmly against the junction; if heavy "rocking" pressure is necessary, either the iron does not have sufficient heat capacity for the job, or it has not been properly prepared, or both.

9–35. HEAT APPLICATION TIME. Do not apply heat to the work any longer than the time necessary to melt the solder on all parts of the joint.

9–36. AMOUNT OF SOLDER. Do not use any more solder than necessary. Do not pile up solder around the joint; this is wasteful, and results in joints difficult to inspect. Care should be exercised with silver coated wire to prevent wicking during solder application.

9–37. SOLDERING IRON HOLDER. When the soldering iron is not in actual use during operations, keep it in a holder such as is shown in figure 9–7. This will protect the operator against burns, and the iron against damage.

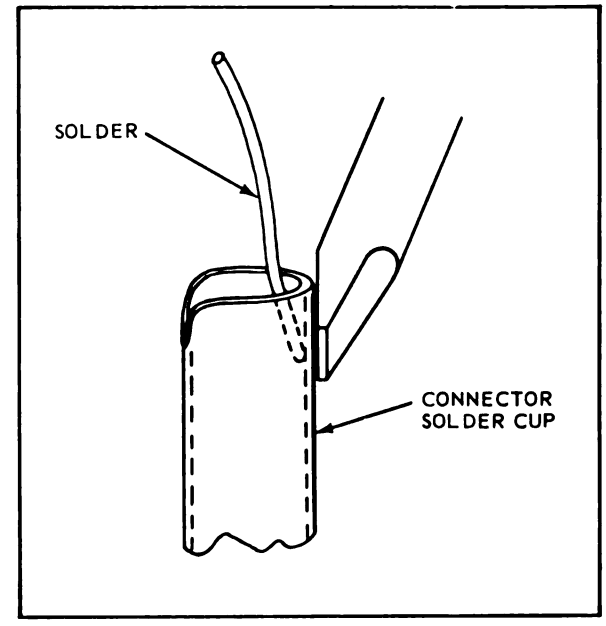


Figure 9–6. Correct Solder Application

9–38. PROTECTION AGAINST OVERHEATING. Do not allow the iron to overheat. Disconnect the iron when it is not in use between operations, or use a heat-dissipating stand which will keep the iron at a constant temperature.

9–39. COOLING THE SOLDER JOINT. When the solder joint has been make, hold the work firmly in place until the joint has set. Disturbing the finished work will result in a joint mechanically weak, and with high electrical resistance. Allow solder joints to cool naturally. Do not use liquids or air blasts.

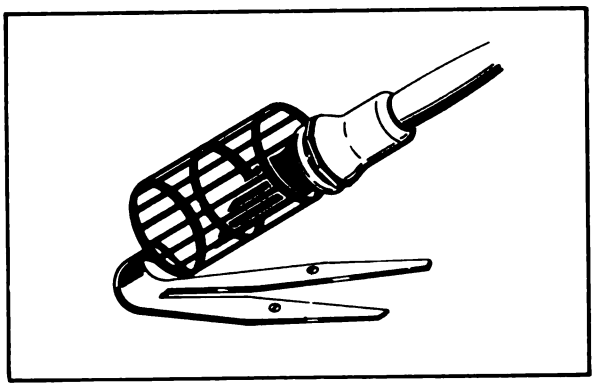


Figure 9–7. Soldering Iron Holder

9–40. CLEANING. If the correct amount of solder is used and procedure instructions followed carefully, there should be little or no excess flux remaining on the finished joint. If cleaning is necessary, remove excessive flux by brushing the joint with a stiff brush dipped in methyl alcohol, methyl isobutyl ketone or a similar approved solvent. Use alcohol sparingly, and avoid contact between alcohol and wire insulation. For cleaning printed circuit connections, use a cotton swab-stick for small areas, and a lint-free clean cloth for large areas and board edges.

9–41. INSPECTING A FINISHED SOLDER JOINT.

9–42. ACCEPTABLE SOLDER JOINT. See figure 9–8. A good soldered joint will have a bright silvery appearance, with smooth fillets and feathered, not sharp edges. The entire joint will be covered with a smooth even coat of solder, and the contour of the joint will be visible.

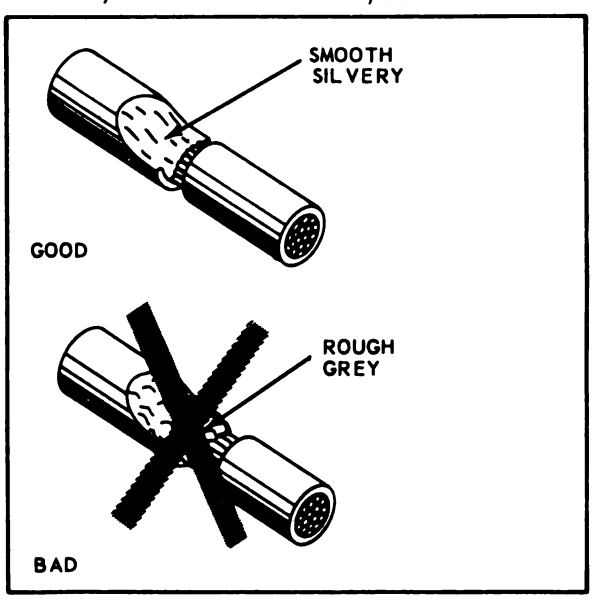


Figure 9–8. Good and Bad Soldered Connections

9–43. UNACCEPTABLE SOLDER JOINT. Any of the following indicate a poor solder joint, and are cause for rejection:

a. Dull gray, chalky or granular appearance, evidence of a cold joint.

b. Hair, cracks, or irregular surface, evidence of a disturbed joint.

c. Grayish, wrinkled appearance, evidence of excessive heat.

d. Partially exposed joint, evidence of insufficient solder.

e. Scorched wire insulation or burned connector inserts.

f. Globules, drips or tails of solder.

If any of the above are present in a finished solder joint, the joint should be taken apart, parts cleaned, and the entire soldering operation repeated, using fresh solder and flux.

9–44. REPAIR AND SOLDERING OF PRINTED CIRCUIT ASSEMBLIES.

9–45. GENERAL. Printed circuit assemblies are used in the aircraft electrical system to save space and weight, to increase reliability and to facilitate replacement. Typical locations are in equipment cases at area termination points of the interconnecting wiring, and in junction boxes at break-out points in the electrical system.

9–46. DESCRIPTION. A printed circuit board consists of a conductor pattern bonded onto an insulating base. Components are mounted on the opposite side from the conductor, and are attached to it by leads through drilled holes or eyelets in the base. A printed circuit board may have conductor patterns on both sides. Each printed circuit board assembly is identified by a number printed on the board, referencing the applicable circuit drawing or schematic.

9–47. FEASIBILITY OF REPAIR. Printed circuit assemblies are repaired and re-soldered to restore them to their original condition when they have been found to be defective or damaged. If the damage or defect is serious or extensive, it may not be practical to rework the board. It is not considered feasible to repair a printed circuit assembly if any of the following conditions could result:

a. Repair is impractical because of its extent.
b. The repair would decrease the life expectancy of any component.
c. The repair could damage adjacent components or circuitry.
d. The operation of the equipment would be changed by the repair.

In any of the above cases, replace the printed circuit assembly with a new identical assembly.

9–48. GENERAL PRECAUTIONS AND PROCEDURES.

9–49. HANDLING PRECAUTIONS. Printed circuit assemblies require very careful handling during repair and soldering operations, or when being installed as a replacement assembly. When handling assemblies withdrawn from cases and junction boxes, or from replacement stores observe the following precautions:

a. Keep the printed circuit assembly in a padded plastic or paper protective bag while awaiting use or repair. Keep in a cool dry place.

b. Carry the assembly by its handle (if present) or by the edges.

c. Do not handle or lift the assembly by any of its mounted components; this can result in broken leads.

d. Do not stack one board on top of another. Always support the board on its long free edge.

e. Never flex, bend or force the base during removal, repair or replacement.

f. Avoid touching the face of the board with the hands, particularly the conductor or exposed contacts of plug-in assemblies and test points. Body acids produce corrosion and cause high resistivity which can affect the performance of the circuit.

g. During repair, use an appropriate holding fixture to support the board by its edges, as shown in figure 9–9. Provide adequate support underneath the board to offset the force of drilling, scraping and component removal or replacement.

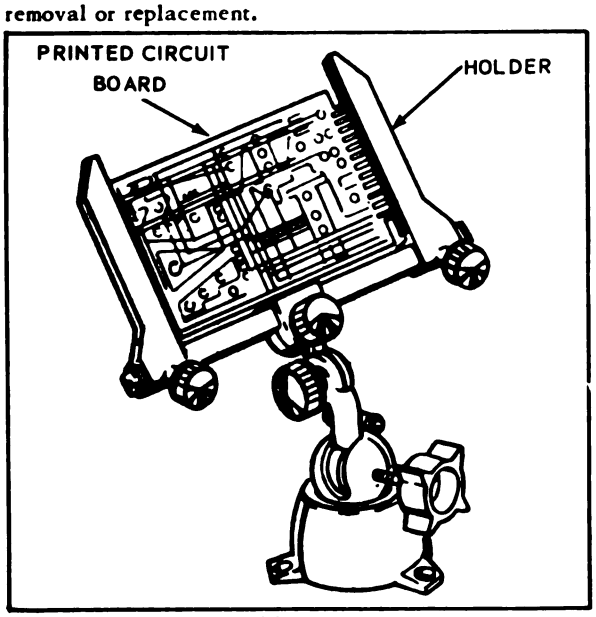


Figure 9–9. Holding Fixture for Printed Circuit Assembly

h. Make sure that all tools used for mechanical repairs are clean. Use only pliers with smooth jaws and radiused edges.

i. Clean with short gentle puffs of low pressure, oil-free, dry air. Avoid violent bursts. Do not clean by ultra-sonic methods, this may affect the laminate.

9–50. DESOLDERING PRINTED CIRCUIT COMPONENTS. When it is necessary to remove components from a printed circuit assembly, their leads or lugs must first be de-soldered, so that the leads or lugs can be readily withdrawn through the board to free the components. The procedures to be used and the precautions to be observed are as follows:

a. To melt the solder, apply the soldering iron tip to the fillet while slowly counting to four, then remove the iron.

CAUTION

Do not exceed this time.

Repeat as necessary, allowing the work to cool between applications. If it is desired to remove the component intact, as for testing, place a heat sink clamp on the lead, as close as possible to the component body befor applying the iron.

b. Use a solder sucker to suck up the solder as it melts. (See figure 9–10a). Compress the bulb, place the tip directly on the liquid fillet, and release the bulb. Repeat as necessary.

c. In open areas, or to remove large terminal areas of soldering, a piece of 1/8 inch tubular electro-tinned braid may be used to remove the liquid solder as shown in figure 9–10b. Flatten 1/4 inch of the braid end, dip sparingly into liquid flux, and place this end against the fillet. When the iron is applied, the solder will be drawn up into the braid as it melts. Cut off the solder-saturated part of the braid and repeat if necessary.

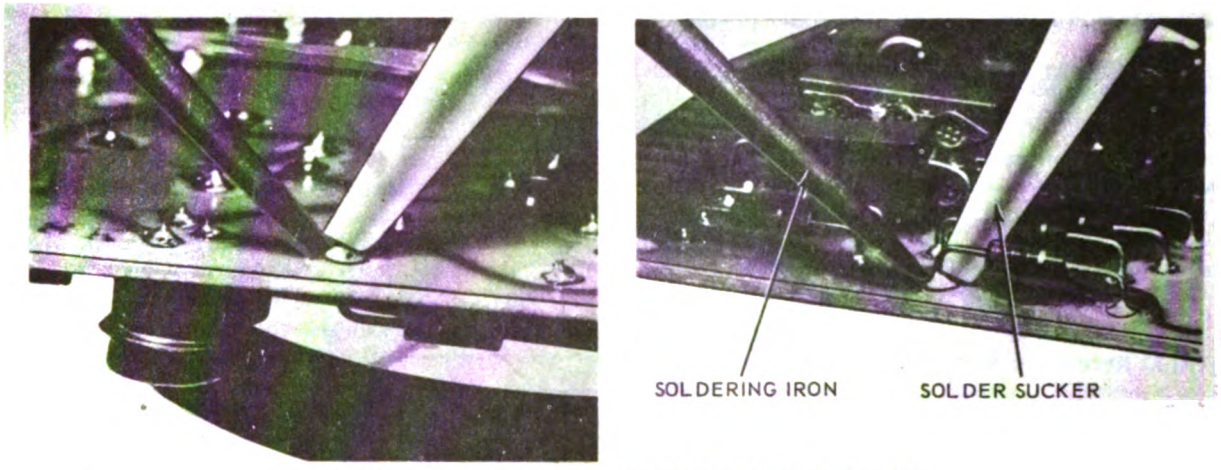
9–51. SOLDERING PROCEDURES. Working space on printed circuit board assemblies is limited because of tightly packed components. The following special procedures will be helpful in soldering operations under these conditions:

a. Fix the board in the holder in such a way that gravity will aid in forming the fillet.

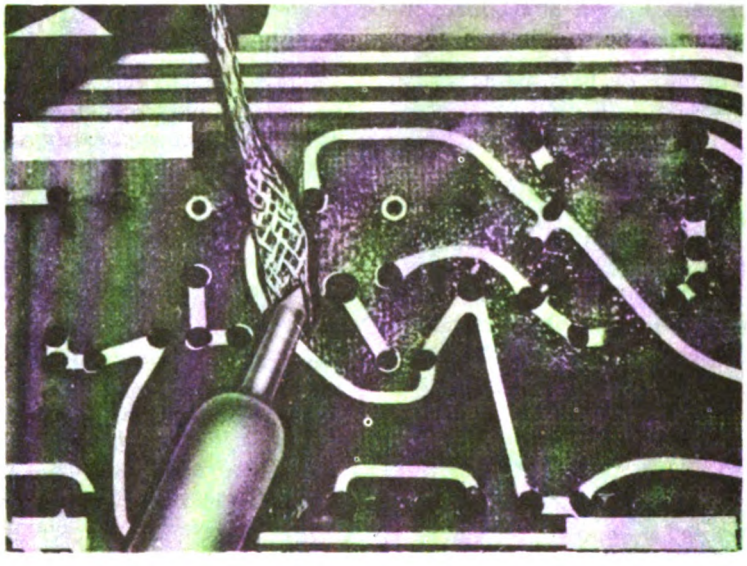
b. Select a tip shape to suit the angle of approach to the work. Use a screw driver tip for an approach perpendicular to the board; use a pyramid shape when the approach is at an angle. (See figure 9–11)

c. Rest the elbow, arm or wrist against the bench top or holding fixture to assist in directing the iron to the work.

d. When soldering, coil the fine diameter cored solder into a small helix for easier handling, and feed from the center of the coil.



a. USE OF SOLDER SUCKER IN DESOLDERING OPERATION



b. REMOVING SOLDER WITH COPPER BRAID

Figure 9–10. Desoldering Printed Circuit Components

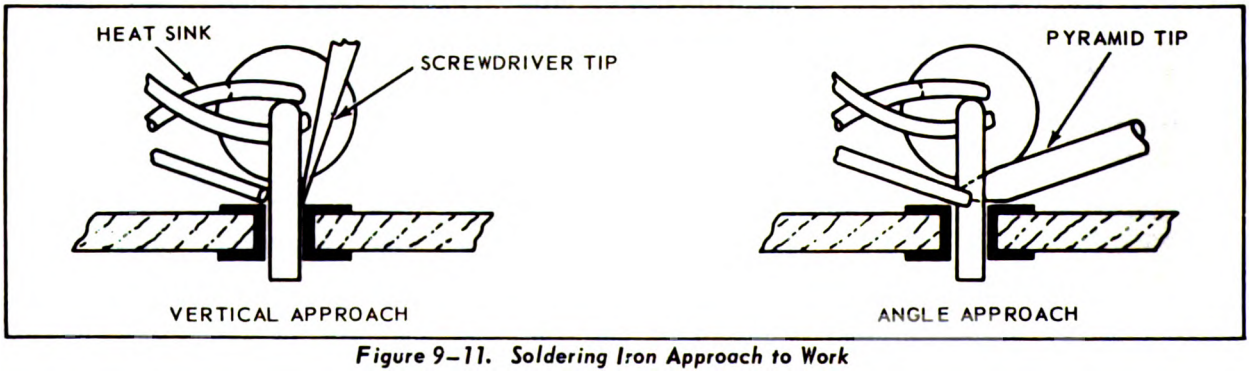


Figure 9–11. Soldering Iron Approach to Work

e. Apply the flat side of the iron against the work with a deliberate touch, not to exceed a slow count of four, until experience dictates the practical limit for the condition.

f. If the solder does not "take", allow the connection to cool, and reapply the iron tip, after adding a small amount of liquid flux. If this does not produce a satisfactory joint, remake the joint.

9–52. SOLDERING PRECAUTIONS. When soldering printed circuits, the completed solder fillet must mechanically bond the component lead or lug to the foil terminal area, and electrically provide a low resistance path between the two. The soldering operation must be carried out without damage to the laminate, foil, and adjacent components. Observe the following precautions in addition to the general precautions listed in 9–24 through 9–30.

a. Make sure that leads are properly dressed and fixed in position before soldering.

b. Use the smallest tip size and shortest heat application time possible to avoid damage to board, foil and components.

c. Use only the solder and flux described in 9–9 through 9–12.

d. Use heat sinks to dissipate excessive heat. Excessive temperature will cause the base/foil laminate to discolor, de-laminate, blister or burn; board components can be damaged or suffer a change in value from over heating.

e. Protect areas adjacent to the soldering operation with light weight sheet asbestos ribbon, cut and shaped around components.

f. Avoid excessive solder or splatter.

g. Be careful not to accidently touch the iron to the cored solder. This may cause the solder to splatter, damaging the work and resulting in painful burns to the operator.

9–53. DETAILED PROCEDURES. The following paragraphs give instructions for typical feasible repair and soldering operations to defective or damaged circuit assemblies. Observe all precautions listed in 9–49 through 9–52.

9–54. REMOVAL OF PROTECTIVE SEALING (CONFORMAL) COATING. Before staring any repair it is necessary to remove the protective coating in the defective area to expose and clean the defect. The procedure is as follows:

a. In open base areas with no adjacent heat sensitive components, remove the coating with a chisel-tip soldering iron, using a push motion as shown in figure 9–12a. Keep the iron moving steadily to prevent heat damage to base or conductor pattern, and to avoid unwanted de-soldering.

CAUTION

Do not attempt removal in a single pass. Complete removal in one area at a time.

b. Clean the area with a scrub brush and approved solvent to remove traces of coating or base material particles.

c. Wipe of excess solvent with cotton swabs, and dry with a lint-free cloth.

d. In congested base areas where heat damage to adjacent components must be avoided, use a hook scraper, with a pull motion as shown in figure 9–12b.

e. Finish and clean out with an angle scraper or knife point. Smooth any remaining rough areas with file or knife blade.

Note

When repairs have been completed, the protective coating must be restored to the reworked area.

9–55. BASE LAMINATE REPAIRS. Before making repairs to conductor patterns, or replacing defective components, repair any physical defects in the base laminate such as chipped edges, edge cracks and gouges or other surface damage. It is not considered feasible to repair base laminate having the following defects:

a. Ruptured conductor pattern, annular rings or terminal areas.

b. Loss of support under printed contacts or connectors.

c. Dangling components.

d. Inadequate guide edge or mounting provisions.

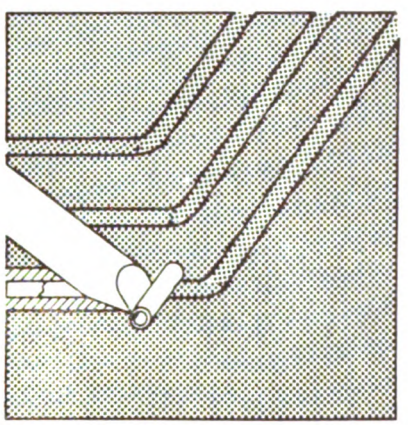
9–56. REPAIR OF CONDUCTOR PATTERN. Feasible repairs to the conductor pattern are of two types: repair of minor defects such as fine cracks, pin holes, ragged edges, scratches, gouges and corrosion; and repair of major defects where the conductor foil, or its bonding is damaged to such an extent that part of it must be replaced with a wire segment. It is not considered feasible to repair annular rings or terminal areas that are incomplete or not bonded to the base. When making repairs to the conductor pattern, observe the following special precautions:

a. Make sure the minimum separation distance between adjacent conductors is not reduced.

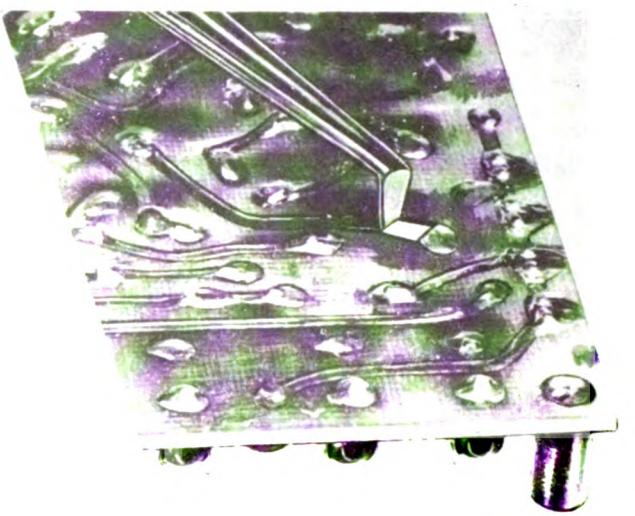
b. Make sure the effective cross-sectional area of the conductor foil is maintained.

c. Make sure that the original conductor dress and routing is adhered to.

9–57. REPAIR OF MINOR CONDUCTOR DEFECTS. The procedure for repairing the minor defects described in 9–56 is as follows: (See figure 9–13a).

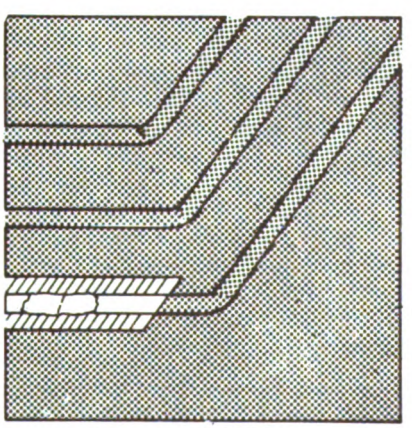


a. REMOVING COATING WITH SOLDERING IRON

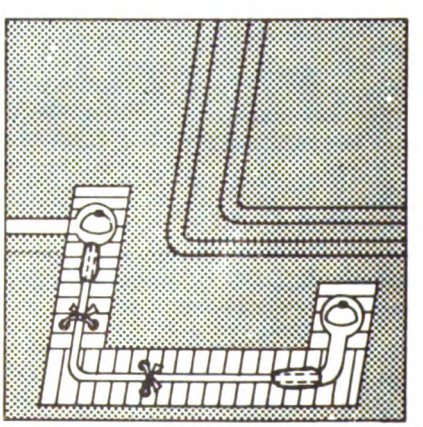


b. REMOVING COATING WITH SCRAPER

Figure 9–12. Removing Protective Coating



a. MINOR DEFECT PATCHED WITH SOLDER



b. MAJOR DEFECT BRIDGED WITH WIRE

Figure 9–13. Repairing Defective Conductor Pattern

a. Bright-clean the defective area; remove all foreign particles by brushing.

b. Apply flux to the repair area; then apply solder to bridge or patch the defective area with a minimum 1/8 inch overlap.

c. Remove solder residue with a solvent-saturated swab, and dry the area.

9–58. REPAIR OF MAJOR CONDUCTOR DEFECTS. The procedure for repairing the major defects described in 9–56 is as follows: (See figure 9–13b)

a. Measure width of damaged conductor, and select a wire of the correct diameter to replace it. This information will be found on the applicable printed circuit assembly drawing.

b. Remove all traces of the damaged part of the conductor from the base, using a sharp knife, scrapers and brushes.

c. Bright-clean the remaining ends of the conductor and remove foreign particles.

d. Cut the replacement wire to length, strip (if insulated) clean, trim and tin ends. Form the wire to the contour of the removed conductor.

e. Apply liquid flux to the wire and conductor ends, and solder.

f. Remove solder residue with a solvent-saturated swab, and dry the area.

g. If necessary, for long wire segments, tie the wire in place with 1/32 inch diameter lacing cord, through a pair of 1/16 inch diameter holes drilled in the base.

Note

Short wire segments will be located and attached to the base by the final protective coating.

9–59. REPAIR OF CONDUCTOR INTERFACIAL CONNECTIONS. Interfacial connections, such as swaged eyelets, and plated-through holes are used to connect the conductor patterns on opposite sides of the base. Surface cracks or imperfect soldering of these, or of component leads and "z" wires used in conjunction with them, may cause discontinuities in the electrical path. The repair procedure is as follows: See figure 9–14.

a. Bright-clean the defective area on both sides of the board.

b. De-solder the connection, using a soldering iron and solder sucker. Remove old fillets and contained solder from inside and around the hole, and from the component lead or "z" wire if present.

c. Inspect eyelet for tightness. If it is not tight, re-set it.

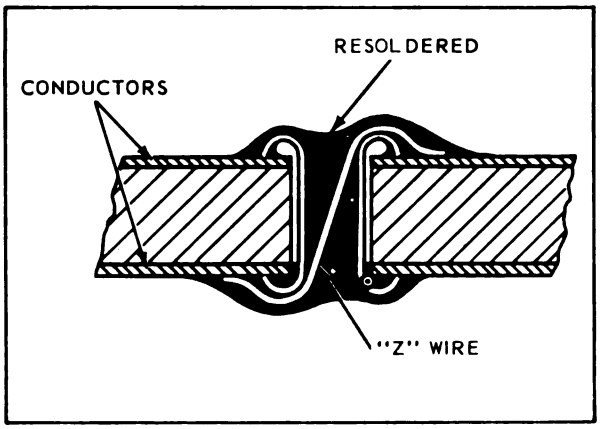


Figure 9–14. Repairing Interfacial Connection

d. If the through hole is an open hole and a "z" wire can be used, cut, form and insert it. Dress both ends on the foil centerlines.

e. Bright-clean both sides of the connection, and re-solder the connections so as to fill the opening, on both sides.

f. Remove solder residue with a solvent-saturated swab, and dry the area on both sides.

9–60. REPLACEMENT OF DEFECTIVE CIRCUIT COMPONENTS. Defective components are removed from the printed circuit assembly, and replaced by a new component identical to the one removed. Components must be removed and replaced without damage to their attachments or to the surrounding area. Observe these special precautions:

a. Make sure that position of replaced component on the board, lead dress and polarity are the same as the original. Position component so that its markings are visible, and that codes or legends on base surface are not hidden.

b. Avoid pressure points where leads may contact other leads.

c. Make sure minimum bend length dimensions for leads are observed.

d. Provide stress relief for stiff leads, when used.

e. Provide insulation where possibility of short circuits exists.

9–61. REPLACEMENT OF LEAD MOUNTED COMPONENTS. The procedures for replacing lead-mounted components such as resistors, capacitors, chokes, etc. are as follows: (See figure 9–15)

a. When the defective unit and its leads are to be entirely removed, cut the leads as shown and discard the component body. Desolder both leads, and extract stubs from component side. Hot ream both terminal holes from conductor side and clip any "icicles" on

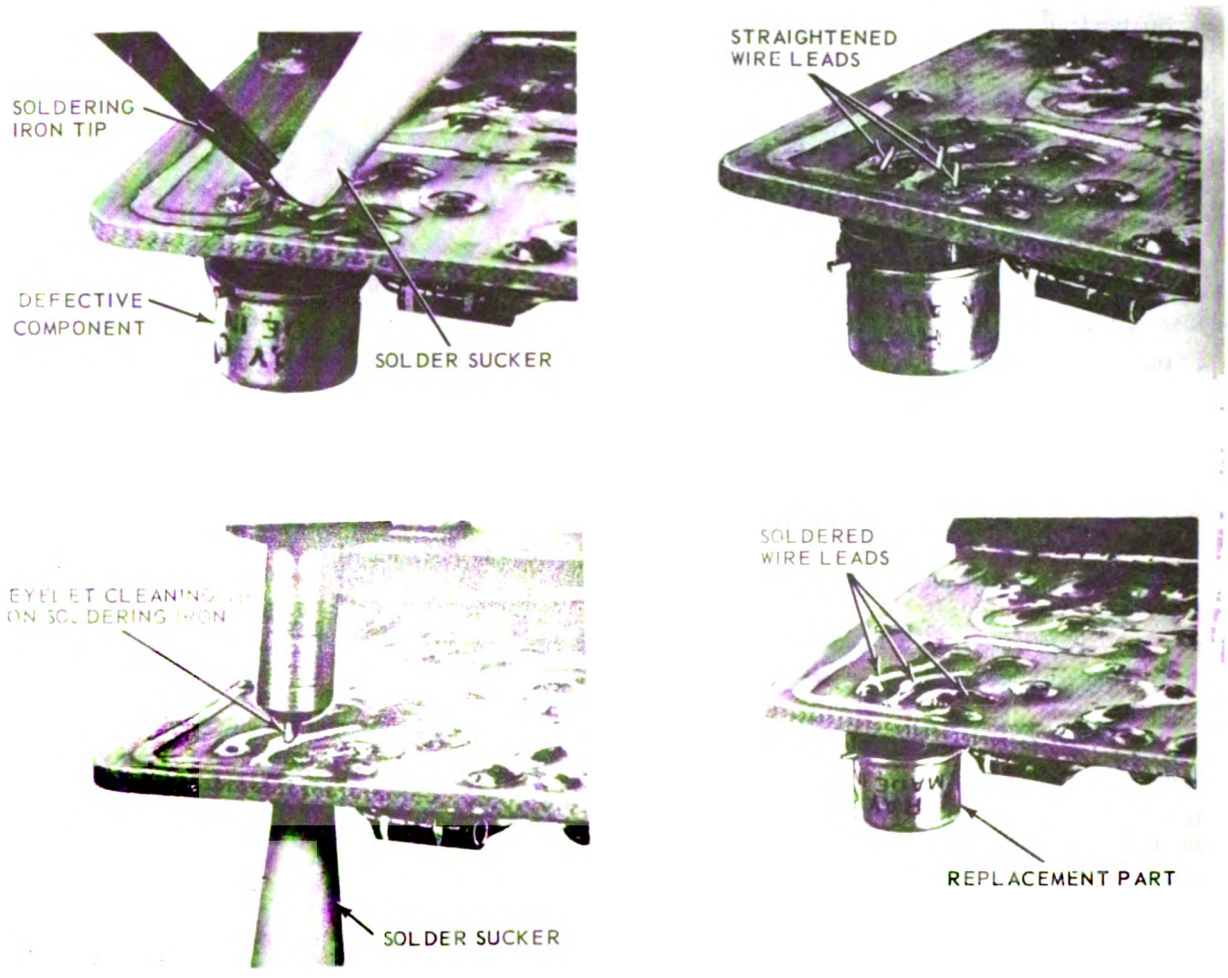


Figure 9–15. Replacing Defective Component

the opposite side. Remove solder residue and dry.

CAUTION

When pulling leads through the board, pull against the side having the smallest foil area, to avoid loosening the foil.

b. When defective unit body only is to be removed, cut the leads close to the body, and discard body. Erect the stubs and bright clean in preparation for soldering.

c. When defective component is a carbon resistor, the body only is removed by destroying it, to leave the longest possible leads. Do this as follows:

1. Position the holding fixture so that crushed body particles will fall free of other components.

2. Use heavy diagonal pliers to crush the body at the center, steadying both leads with the other hand.

3. Crush any body material adhering to the upper ends of the two leads.

4. Erect the stubs and bright-clean in preparation for soldering.

5. Remove all foreign particles and dust from the assembly.

Note

After each of the above procedures inspect the repair area on both sides of the base for overall integrity and next step readiness.

d. When component leads have been completely removed as described in step a, insert the replacement component leads in the mounting holes. Wedge and secure the component at the required base clearance and solder to the base.

e. When lead stubs have been left attached to the board as described in step b, form loops at ends of re-

placement component leads, crimp around stubs and solder.

9-62. REPLACEMENT OF LUG MOUNTED COMPONENTS. The procedure for replacing lug-mounted components is as follows:

a. De-solder the lug from the base, and suck up liquified solder with a solder-sucker.

b. If the lug is crimped over, re-heat the connection and straighten out the lug with a probe prong.

c. Apply the iron to the lug, then place the solder-sucker tip down around the lug to draw up any remaining solder.

d. With a sharp narrow knife blade, cut through any crystallized solder bridging the lug and foil terminal area. Make cuts next to and parallel with the lug, cutting into the lug base hole clearance.

e. Free the lug from the base.

CAUTION

Take care not to damage the conductor foil.

f. Position the replacement component to pass the lugs through their base holes. Wedge and secure the component so the lugs cannot shift.

g. Trim and form the lugs as necessary.

h. Make sure lugs and terminal area are clean, then solder, using heat sink if necessary.

SECTION X

ELECTRIC CONNECTOR SEALING

10-1. INTRODUCTION.

10-2. GENERAL. Sealing compound is used to moisture-proof the wiring connected to the backs of electric connectors, and to reinforce the backs of connectors against failure caused by vibration and lateral pressure which fatigue the wire at the solder cup. This process is commonly called potting. The sealing compound protects electric connectors from corrosion or contamination by excluding metallic particles and aircraft liquids, and also reduces the probability of arc-over between pins on the back of the connector.

10-3. SCOPE. This section describes the potting compounds used on aircraft electric connectors, and gives instructions for preparing and storing the compound. Detailed instructions for potting MS Electric Connectors are given in section III.

10-4. REFERENCE SPECIFICATIONS.

MIL-S-8516 Sealing Compound, Synthetic Rubber, Electric Connectors and Electric Systems, Accelerator Required.

Navy/BuWeps EMC No. 89-55 Electric Connector Sealing.

MIL-S-23586 Sealing Compound, Electrical, Silicone Rubber, Accelerator Required.

10-5. DESCRIPTION. Sealing compound in accordance with military specification MIL-S-8516 is a two-part thiokol rubber compound, consisting of a base and an accelerator (curing agent), packaged together. This compound is used to seal connectors located in areas where the ambient temperature does not exceed 200 degrees F. Sealing compound in accordance with Military Specification MIL-S-23586 is a three-part system silicone rubber compound consisting of a silicone base, primer and vulcanizing agent (curing agent) packaged together. This compound is used to seal connectors located in areas where the temperature exceeds 200 degrees Fahrenheit. In its cured condition, the sealing compound is specified for the temperature ranges from −80°F to +400°F and resists temperatures to 500°F.

Note

Sealing compound is not applied to the following connectors:
a. Environment proof type "E" and "R" connectors.
b. Coaxial connectors.
c. Connectors with crimped contacts.

10-6. HIGH TEMPERATURE SEALING COMPOUND. The Government specification for an electric connector sealing compound for use where the ambient temperature is expected to exceed 200 degrees Fahrenheit is MIL-S-23586 (refer to paragraph 10-5 above).

10-7. GENERAL PRECAUTIONS.

10-8. Potting compound is supplied in paired cans of base compound and acclerator. Use only the accelerator supplied with the base compound. Substitution may produce a sealant with substantial electrical properties. To avoid errors, store base and accelerator together in the carton.

10-9. Make sure that the entire amount of accelerator is mixed into the entire amount of base. Any change in proportion will affect electrical properties of the sealant, and may also affect the work life, rate of cure and hardness of the compound.

10-10. The sealant contains a small quantity of volatile flammable solvent. Observe adequate ventilation and fire precautions during mixing and storage.

10-11. PREPARATION OF SEALING COMPOUND.

10-12. HAND MIXING PROCEDURE. Add the accelerator to the base compound as follows:

a. Remove lid from accelerator container and stir contents slowly into a smooth creamy paste with a clean spatula, wood tongue depressor or putty knife.

WARNING

The accelerator contains a lead compound. Wear rubber gloves to avoid excessive skin contact, and clean hands thoroughly after handling.

b. Cut top from base compound container and stir contents until material has a smooth texture. This is necessary to recombine material which may have settled out.

c. Combine accelerator and base material and thoroughly agitate or mix until no accelerator streaks or traces of unmixed material are visible. Mix slowly, do not beat or whip; fast mixing may cause excessive amounts of air to become trapped in the compound. Mixing normally requires five to eight minutes. Con-

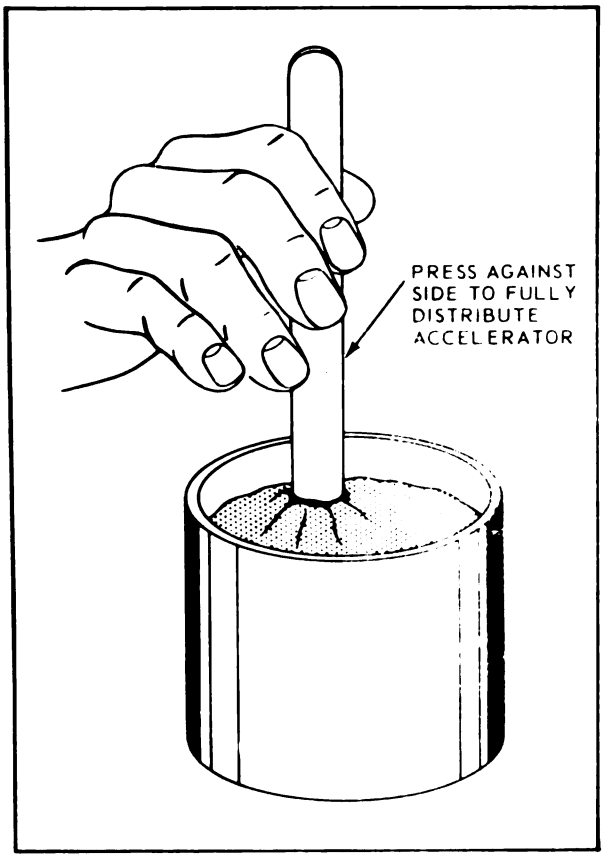


Figure 10–1. Hand Mixing Potting Compound

tinued scraping of the sides and corners of the bottom of the container will insure complete mixing. (See figure 10–1).

d. Determine if mixing is complete by spreading a drop of the mixture very thinly on a piece of white paper with a knife blade or similar instrument. Close examination should not reveal any specks or streaks. Do not mix the sealant beyond the point where tests show the accelerator to be thoroughly mixed into the base compound.

e. When the mixing procedure has been completed the sealant is ready for use and may be poured directly into the connector to be sealed. For details of connector sealing, see section III, paragraph 3–62.

f. If the mixed compound is not to be used immediately, store it as directed in 10–18.

10–13. MECHANICAL MIXING PROCEDURE. Mechanical mixing should be done at 60 degrees F or lower to prolong the working life of the sealant. The procedure is as follows:

a. Hand mix the accelerator as described in 10–12a. A paint shaker vibrating machine may be used if available. Shake for five to seven minutes.

b. If the base material is packaged in a metal can, cut off the top of the container using a mechanical can opener. This should leave a smooth wall without any burr at the top of the can.

c. Clamp base material container securely to drill press geared to 50 PRM minimum to 90 RPM maximum. Insert a mixing paddle fashioned from a drill rod and wire. (See figure 10–2.)

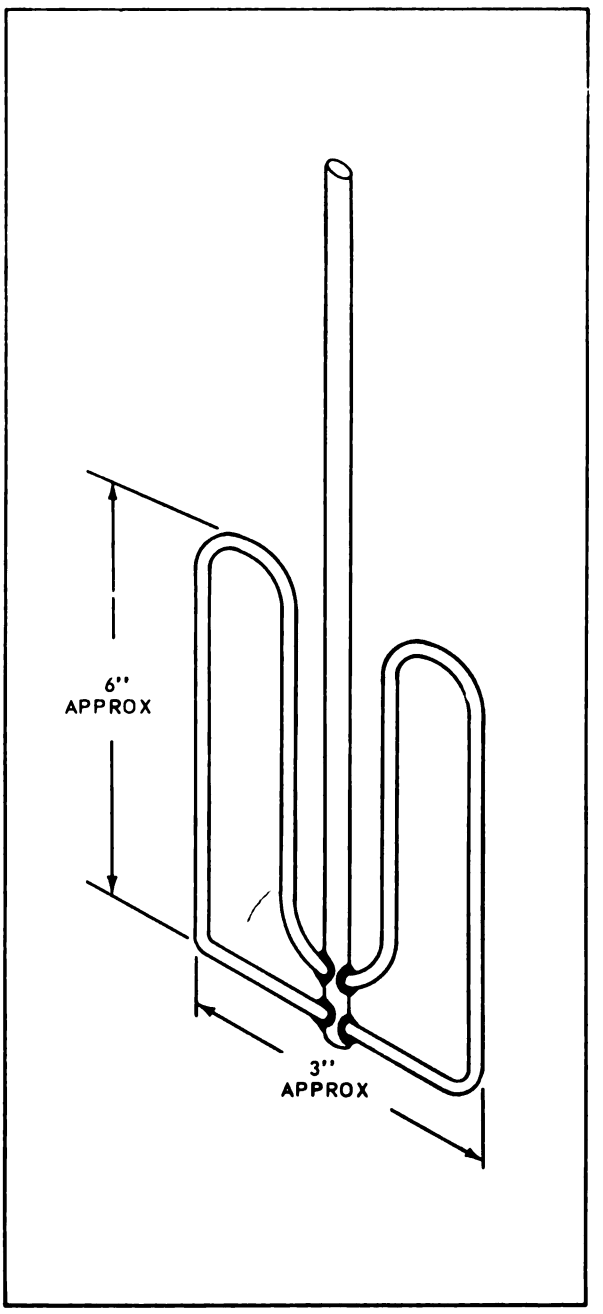


Figure 10–2. Mixing Paddle for Potting Compound

d. Start drill press motor and slowly lower mixing paddle into the base compound to recombine any material which may have settled out.

e. Scrape all accelerator from its container and place it in the base material. Start drill press motor again and mix slowly for approximately two minutes. Stop machine, raise paddle and scrape container walls and paddle as clean as possible. Start the drill press and lower the mixing paddle again and continue mixing for as additional three minutes.

f. Make thin spread of sealant on white paper as described in 10–12d. If necessary, continue mixing in two minute cycles followed by paper test until no traces of unmixed material are visible. The sealant is then ready for use.

g. If the mixed compound is not be used at once, store in accordance with instructions in 10–18.

10–14. MACHINE MIXING. See figure 10–3. This machine will mix up to one quart of potting compound, and inserts the mixture under pressure into a cartridge for use with a sealant gun, if desired. The procedure is as follows:

a. Set the pressure regulator to the pressure recommended by the manufacturer of the compound being used.

b. Check that the dasher control valve lever is up, cartridge filler valve closed, (handle horizontal), and pressure control valve lever down.

c. Remove the container from the machine; place half the base material in the container, and add the accelerator in the center (not in contact with the container). Add the rest of the base material, and replace the container in the machine.

d. Raise the pressure control valve lever slightly so that the container rises slowly. When the container stops moving, push the lever all the way up, so that full pressure is acting against the material.

e. Set the cycle counter to zero, and move the dasher control valve lever down to start the mixing cycle.

f. After the counter indicates the completion of the required number of cycles, as recommended by the compound manufacturer, place a sealant gun cartridge, with plunger inserted, horizontally over the filler valve outlet, and open the filler valve while the machine is still mixing. Squeeze the cartridge slightly to force out air. When the dasher stops, the cartridge will be filled, and the container empty.

Note

The machine should be thoroughly cleaned in accordance with manufacturer's instructions after each series of mixings.

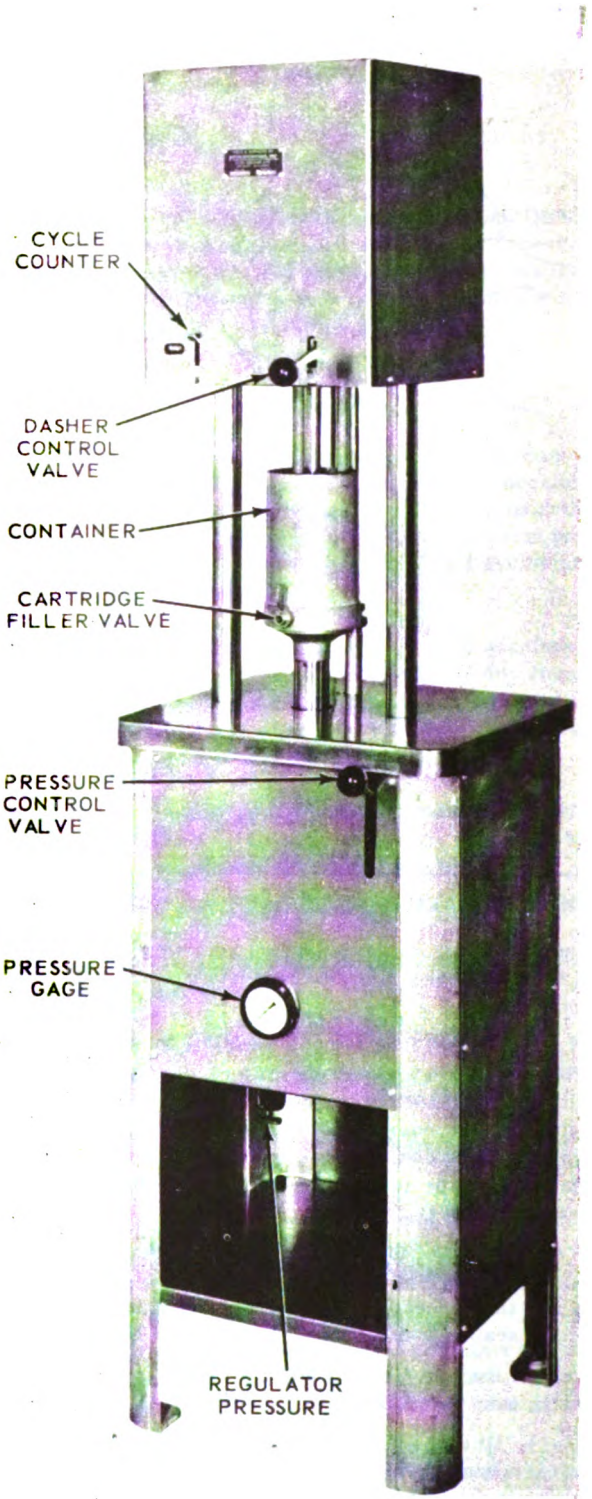


Figure 10–3. Machine for Mixing Potting Compound

10–15. PREPARATION OF HIGH TEMPERATURE SEALING COMPOUND. Mix high temperature sealing compounds in the proportions as directed or supplied by the manufacturer, using one of the three methods described in 10–12 through 10–14.

10–16. STORAGE OF SEALING COMPOUND.

10–17. STORAGE OF UNMIXED SEALING COMPOUND. Store base compound and accelerator in a cool place. Shelf life is approximately one year when stored below 75 degrees F.

CAUTION

Do not store sealing compound at temperatures high than 80 degrees F.

Keep base compound and accelerator together in the carton as furnished. Note manufacturing date stamped on carton, and use oldest material first.

Note

Do not use sealing compound which is over one year old.

10–18. STORAGE OF MIXED SEALING COMPOUND. Mixed potting compound can be stored for a maximum of 36 hours in a deep freezer at -20°F. Mixed compound has a 90 minute working life at 75 degrees F, and 50% relative humidity. This time is computed from the instant that the accelerator is added to the base compound and must include the time of mixing and use. If the mixed compound is to be stored, it must be cooled quickly and thawed quickly to avoid wasting the short working life. Thaw the mixed compound by blowing compressed air on the outside of the container. Never blow compressed air into the container or use heat to raise its temperature. The compound should be warm enough for use in 5 to 10 minutes.

10–19. DISPENSERS FOR SEALING COMPOUND. Potting compound once mixed should be immediately poured into dispenser tubes made of polyethylene, TFE or aluminum. If necessary to store mixed compound in accordance with 10–18, the compound should first be poured into the final dispenser tube.

Note

Naval activities should follow BuWeps EMC No. 89-55 for dispensers.

Aluminum tubes (figure 10–4), for use when handling small quantities of potting compound are similar to toothpaste tubes. These tubes are 2" in diameter and 10" long. Fold over the filling end and seal before storing. A simple key, as shown in figure 10–4 can be used to wind up the tube and force out the sealing compound.

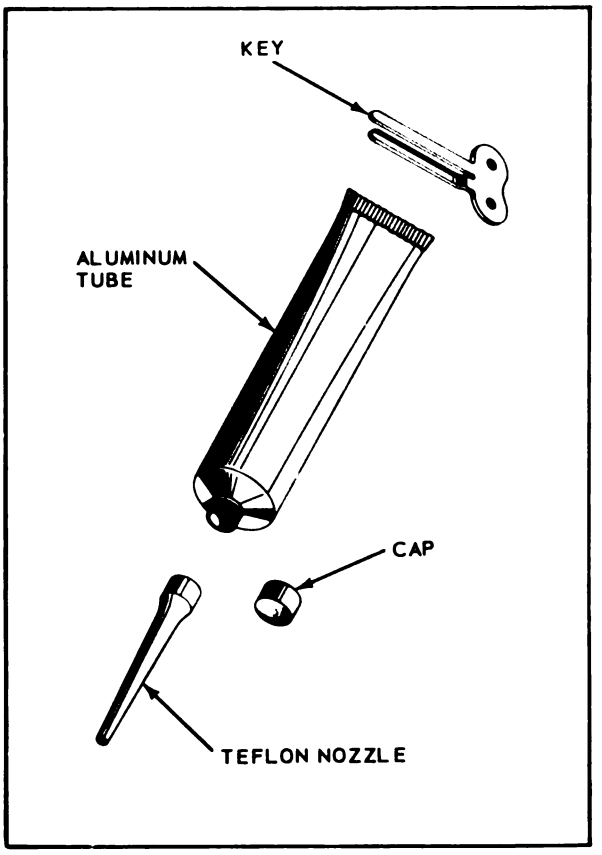


Figure 10–4. Tube Dispenser for Potting Compound

10–20. PREPARATION OF TFE-INSULATED WIRE FOR POTTING. Because of its chemical composition TFE insulation on high temperature electrical wire does not adhere well to potting compound. Pre-treated TFE wire is available from some wire manufacturers, or the TFE insulation may be treated with a sodium etch solution before potting. Follow the directions given by the manufacturer of the solution.

SECTION XI

CONDUIT FABRICATION

11-1. INTRODUCTION.

11-2. PURPOSE. Conduit is used to protect electric wire and cable from abrasion, corrosive fluids, high temperatures, RF interference and damage from cargo handling or activities of aircraft personnel. Extensive use of conduit is undesirable because of weight. Therefore conduit is used only in areas where harmful conditions exist, in parts of aircraft hard to get at for permanent installation and in as short runs as compatible with its protective function.

11-3. SCOPE. This section outlines recommended procedures for the preparation and fabrication of conduit. For installation of conduit into the aircraft see section XIII.

11-4. CONDUIT TYPES. Conduit is available in metallic or non-metallic (plastic) form. Metallic conduit is either rigid or flexible; non-metallic conduit is flexible.

11-5. REFERENCE SPECIFICATIONS AND DRAWINGS.

MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Non-rigid
JAN-A-669	Anti Seize Compound
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-C-6136	Conduit, Flexible, Shielded, Aluminum Alloy
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
MIL-C-7931	Conduit, Electrical, Flexible, Radio Frequency Shielding
MIL-I-23053	Insulation Sleeving, Electrical, Flexible, Heat-Shrinkable
MS 25064	Conduit Flexible, Radio Frequency Shielding
MS 25065	Ferrule-Flexible Conduit, Radio Frequency Shielding
MS 25066	Nut-Flexible Conduit, Radio Frequency Shielding
MS 25067	Conduit Assembly-Flexible, Radio Frequency Shielding
AN3048	Ferrule-Conduit, Flexible, One step Synthetic Covered
AN3050	Ferrule-Conduit, Flexible
AN3051	Ferrule-Conduit, Flexible, One step
AN3052	Ferrule-Conduit, Flexible, Two step
AN3053	Ferrule-Rigid Conduit
AN3054	Nut-Conduit Coupling
AN3083	Ferrule-Conduit, Flexible, 2 - step, Synthetic Covered
AND10106	Tubing-Standard Sizes for Aluminum Alloy (52S0 Round)
AND10380	Fitting Installation Standard AN Conduit
AND10391	Conduit Assembly-Flexible Metallic

11-6. METALLIC CONDUIT.

11-7. GENERAL. Metallic conduit is either rigid or flexible. Regid metallic conduit is aluminum alloy tubing and confirms to the requirements of Standard Drawing AND10106. Aluminum Flexible conduit conforms to Military Specification MIL-C-6136, which covers two types: Type I-Bare Flexible Conduit, and Type II-Rubber Covered Flexible Conduit. Brass flexible conduit conforms to Military Specification MIL-C-7931 and Military Standard Drawing MS 25064. Flexible aluminum conduit is used only when it is impracticable to use rigid conduit, such as in areas where the necessary bends are so complex as to interfere with installation, or where there is relative motion between the conduit ends. Flexible brass conduit is used instead of flexible aluminum in areas where it is necessary to minimize RF interference.

11-8. SELECTION OF CONDUIT SIZE. The protected wire or wire bundle diameter must not be more than 80% of the inside diameter of the conduit. (See figure 11-1).

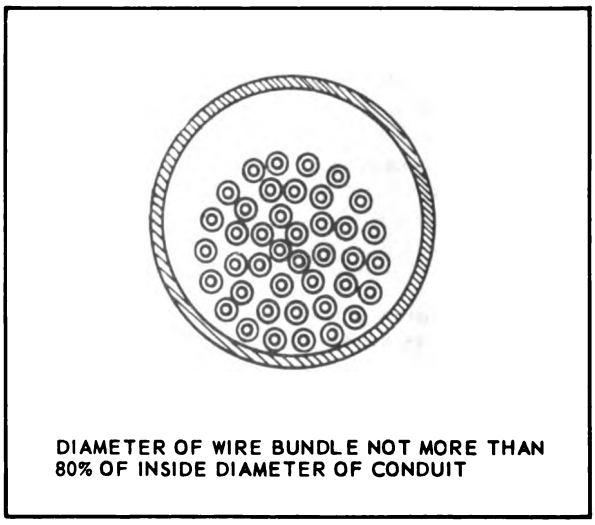


Figure 11-1. Capacity Limits for Conduit

Note

Rigid metallic conduit is supplied in outside diameter sizes. Subtract twice the wall thickness to obtain the inside diameter. Flexible metallic conduit is supplied in inside diameter sizes; no calculation of diameter is necessary.

Determine conduit length to accomodate length of wire to be installed in conduit between connections, so that when conduit is installed there is no strain on the wires.

11–9. PREPARATION OF RIGID METALLIC CONDUIT. Prepare rigid metallic conduit for fabrication as follows:

a. Cut conduit to a length approximately 10% greater than estimated required length using tubing cutter or hack saw.

Note

It is not necessary to clean up conduit ends at this point.

b. Make required bends in conduit, using a hand tube bender as illustrated in figure 11–2. Each nominal tube size requires a different bender to get the proper bend radius. See table 11–1 for minimum bend radii allowable for rigid conduit.

TABLE 11–1

Bend Radii for Rigid Conduit

Nominal Tube OD	Minimum Bend Radii (Inches)
1/8	3/8
3/16	9/16
1/4	3/4
3/8	1–1/8
1/2	1–1/2
5/8	1–7/8
3/4	2–1/4
1	3
1–1/4	3–3/4
1–1/2	4–1/2
1–3/4	5–1/4
2	6

CAUTION

When replacing rigid conduit with fittings at both ends make bends as in the original installation. Rigid conduit with fixed end connections must have at least one bend in the run. It cannot be cut or installed accurately enough to avoid mechanical strain on the tubing or fittings. When installing new rigid conduit, avoid a straight path between fixed connections.

c. Examine conduit bends for cracks, and for flattening which may reduce the area. When tubing is flattened into an ellipse whose minor diameter is 75% of the nominal tubing diameter, the area is reduced by 10%. If the conduit is flattened more than this, reject it. See figure 11–3 for examples of good and bad bends.

d. Cut conduit to final length with a tubing cutter as shown in figure 11–4. If a tubing cutter is not available use a hack saw with 32 tooth blade.

e. File cut ends of conduit square with a fine toothed flat file. If a hack saw has been used, file the ends of the conduit until all saw marks have been removed.

f. Remove burrs from conduit end with a deburring tool. If this is not available, use a file on outside surfaces nnd taper reamer on the inside surfaces.

CAUTION

Make sure all sharp edges are removed from conduit ends as they may cut the wire insulation.

11–10. FABRICATION OF RIGID METALLIC CONDUIT. If rigid metallic conduit is to be assembled to a box connector, select a ferrule and nut of the proper size from table 11–2. Slide the nut back onto the conduit, and install ferrule on cut end, as shown in figure 11–5. Connection is tightened when nut is coupled to box connector at assembly. When rigid conduit is not to be attached to a box connector, flare the ends with a spinning tool as shown in figure 11–6.

TABLE 11–2

AN Fittings for Rigid Conduit

Nominal Conduit Size (OD inches)	Ferrule	Coupling Nut
3/16	AN3053–3	AN3054–3
1/4	AN3053–4	AN3054–4
3/8	AN3053–6	AN3054–6
1/2	AN3053–8	SN 3054–8
5/8	AN3053–10	AN3054–10
3/4	AN3053–12	AN3054–12
1	AN3053–16	AN3054–16
1–1/4	AN3053–20	AN3054–20
1–1/2	AN3053–24	AN3054–24
1–3/4	AN3053–28	AN3054–28
2	AN3053–32	AN3054–32
2- 1/2	AN3053–40	AN3054–40

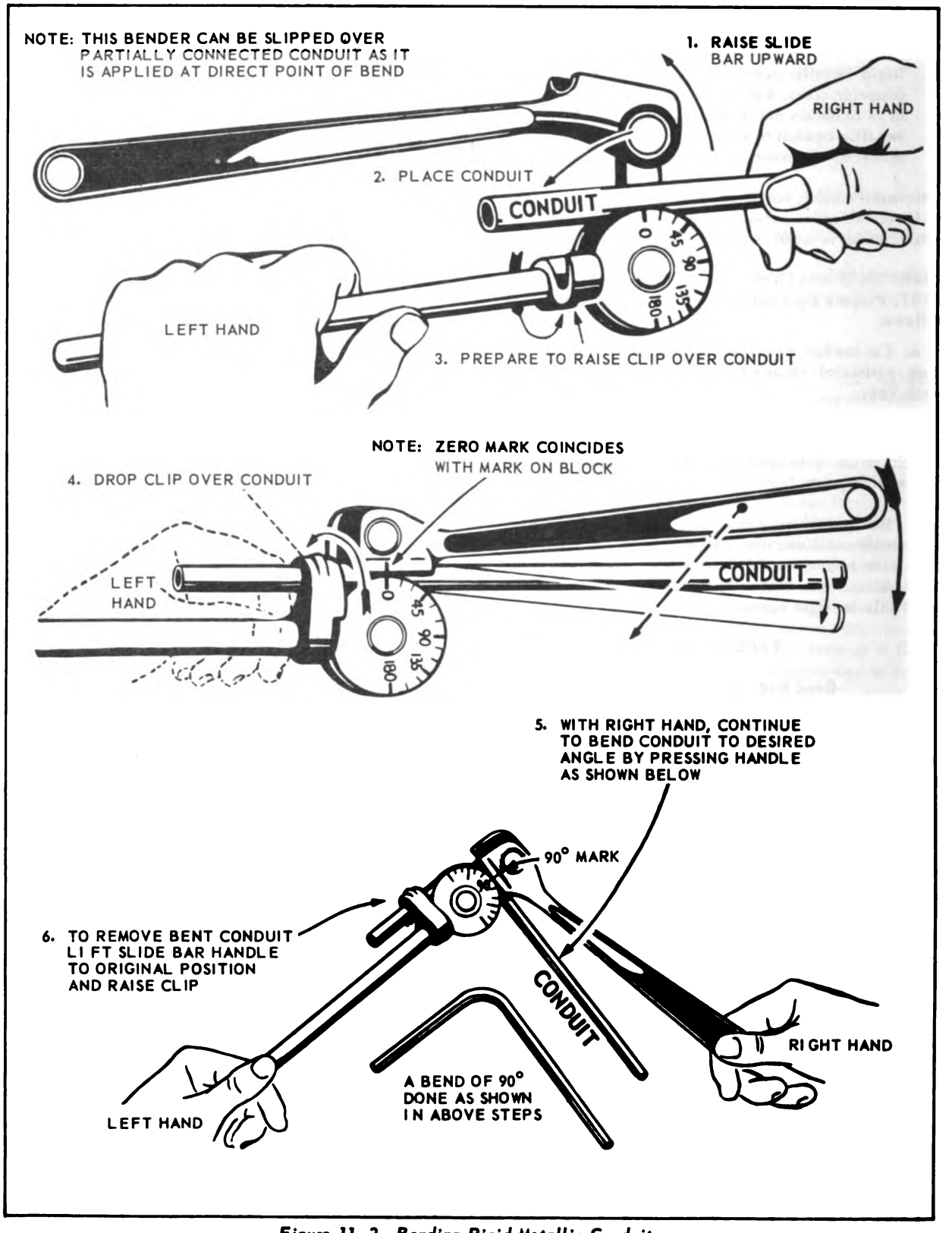


Figure 11–2. Bending Rigid Metallic Conduit

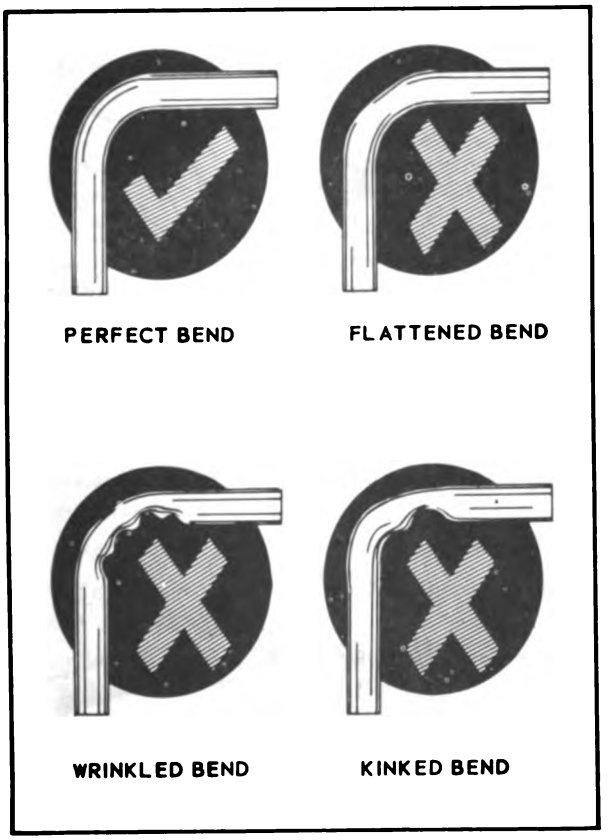


Figure 11–3. Good and Bad Conduit Bends

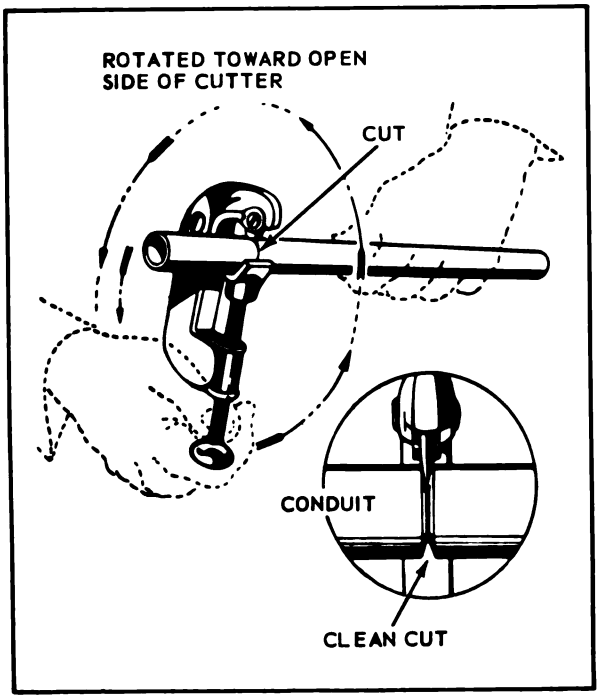


Figure 11–4. Cutting Rigid Metallic Conduit

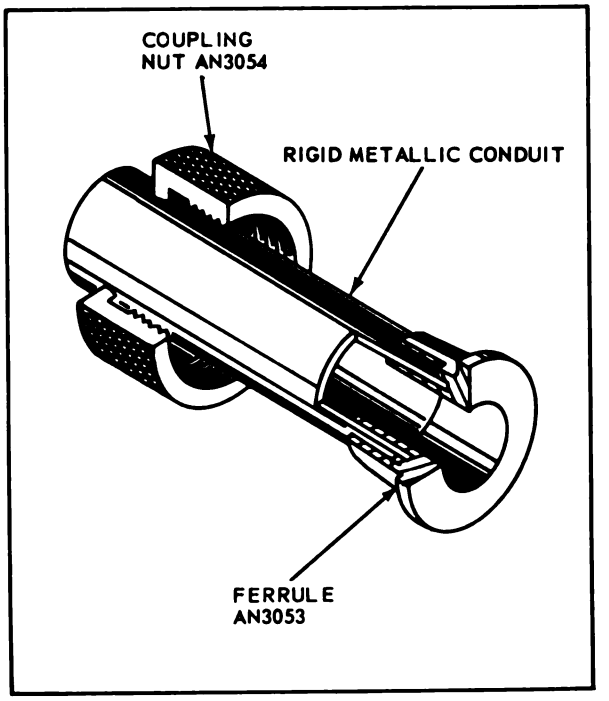


Figure 11–5. Installing Nut and Ferrule on Rigid Metallic Conduit

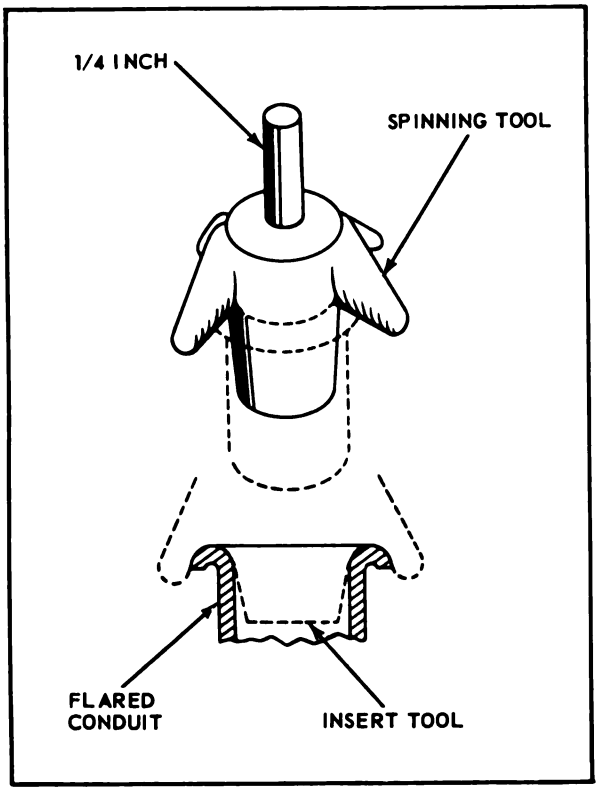


Figure 11–6. Flaring Rigid Metallic Conduit

11-11. PREPARATION OF FLEXIBLE ALUMINUM CONDUIT FOR AMPHENOL ASSEMBLY MACHINE. Prepare flexible aluminum conduit prior to fabrication as follows:

a. Extend conduit to remove slack and mark length to be cut.

b. Place a tight wrap of transparent adhesive tape around bare conduit at marked point, so that cut will be made through center of tape. The tape will minimize fraying of the braid during the cutting operation. Do not tape rubber covered conduit.

c. Place conduit in appropriate slot of saw vise adapter. The adapter insures that a square cut will be made.

d. Cut through conduit with a hack saw as shown in figure 11-7.

e. Remove tape, if used, from conduit ends.

f. Trim frayed ends of braid with end nippers or shears. See figure 11-8.

g. Remove all burrs from inside of conduit at each end with a knife or fine cut round file.

h. For rubber covered flexible conduit, strip rubber cover with a knife, or with a stripping fixture as shown in figure 11-9. See table 11-3 for stripping length.

CAUTION

Do not cut or nick braid.

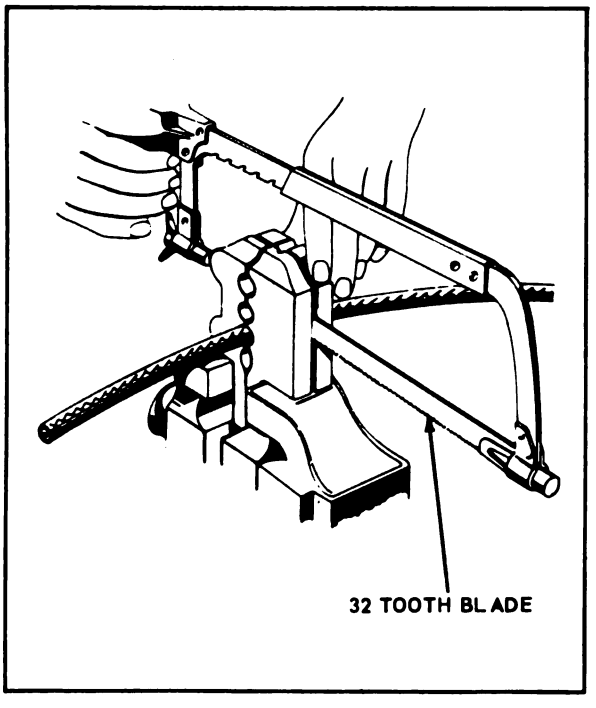


Figure 11-7. Cutting Flexible Conduit

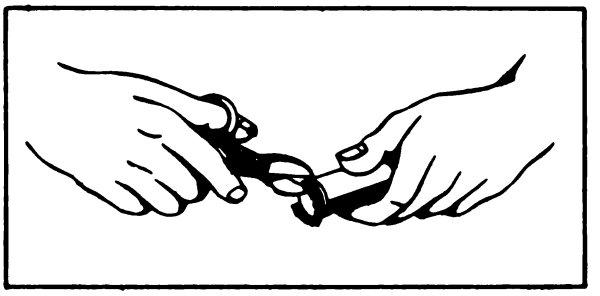


Figure 11-8. Trimming Frayed Ends of Flexible Conduit

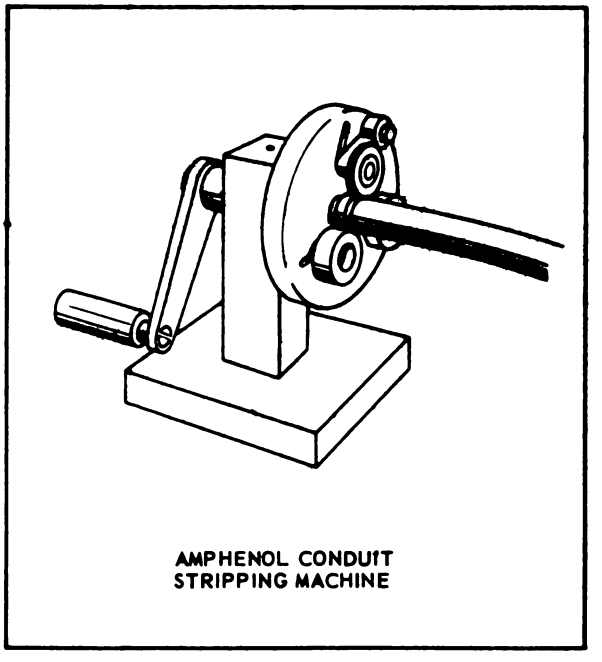


Figure 11-9. Stripping Rubber Cover from Flexible Conduit

TABLE 11-3

Stripping length for Rubber-Covered Flexible Conduit

Nominal Conduit Size (inches)	Stripping Length (inches)
3/16	7/32
1/4	7/32
3/8	7/32
1/2	7/32
5/8	7/32
3/4	1/4
1	5/16
1-1/4	5/16
1-1/2	3/8
1-3/4	7/16
2	1/2
2-1/2	1/2

11–12. PREPARATION OF FLEXIBLE ALUMINUM CONDUIT FOR BREEZE SWAGING MACHINE. Prepare flexible aluminum conduit prior to fabrication, as follows:

a. Extend conduit to remove slack, and mark length to be cut.

b. Place a tight wrap of transparent adhesive tape around bare conduit at marked point, so that cut will be made through center of tape. The tape will minimize fraying of the braid during the cutting operation. Do not tape rubber covered conduit.

c. Place conduit in appropriate slot of saw vise adapter. The adapter insures that a square cut will be made.

d. Cut through conduit with a hack saw as shown in figure 11–7.

e. Remove tape, if used, from conduit ends.

f. Trim frayed ends of braid with end nippers or shears. See figure 11–8.

g. Remove all burrs from inside of conduit at each end with knife or fine cut round file.

Note

The following steps apply only to rubber covered flexible conduit.

h. Trim off rubber cover 1/8 inch with a knife or stripping fixture as shown in figure 11–9.

CAUTION

Do not nick or cut braid.

i. Slide collar selected from table 11–4 on conduit.

j. Roll the rubber back on itself so that approximately 1-7/8 inch of braid is exposed.

TABLE 11–4

Collars for Rubber-Covered Flexible Aluminum Conduit used with Breeze Swaging Machine

Nominal Conduit Size	Aluminum Collar (Breeze No.)
3/16	117–3–A0187
1/4	117–3–A0250
3/8	117–3–A0375
1/2	117–3–A0500
5/8	117–3–A0625
3/4	117–3–A0750
1	117–3–A1000
1–1/4	117–3–A1250
1–1/2	117–3–A1500
2	117–3–A2000
2–1/2	117–3–A2500

11–13. PREPARATION OF FLEXIBLE BRASS CONDUIT FOR BREEZE SWAGING MACHINE. Prepare brass conduit prior to fabrication, as follows:

a. Extend conduit enough to remove slack, and mark length to be cut, plus one inch to allow for fraying of strands during solder dip operation (one half inch will be removed from each end of conduit after solder dip operation.)

b. Place conduit in appropriate slot of saw vise adapter. The adapter insures that a square cut will be made.

c. Cut through conduit with a hack saw as shown in figure 11–7.

Note

Steps d, e & f, apply only to rubber covered brass flexible conduit.

d. Trim of rubber cover 5/8 inch with a knife or trimming fixture as shown in figure 11–9.

e. Slide collar selected from table 11–10 on conduit.

f. Roll rubber back on itself so that approximately 3-3/8 inch of braid is exposed.

g. Tin ends of conduit in solder pot using rosin-alcohol flux and 50/50 tin-lead solder. Tin approximately one inch at each end.

h. Cut approximately one half inch from each end of the conduit, as described in steps b and c, to required length.

i. Trim frayed ends of braid with end nippers or shears as shown in figure 11–8.

j. Remove all burrs from inside of conduit at each end, using a knife or fine cut round file.

11–14. SELECTION OF FITTINGS FOR FLEXIBLE ALUMINUM CONDUIT. Select a ferrule and nut of the required type and size from table 11–5 for bare aluminum (Type I) conduit, or from the table 11–6 for rubber covered aluminum (Type II) conduit.

Note

Select collar from table 11–4, in addition to above, for rubber covered conduit if Breeze swaging machine is used.

TABLE 11-5

AN Fittings for Bare Aluminum (Type I) Flexible Metallic Conduit

Nominal Conduit Size	Regular Ferrule	One-Step Up Ferrule	Two-Step Up Ferrule	Nut
3/16	AN3050-3	–	–	AN3054-3
3/16	–	AN3051-3	–	AN3054-4
1/4	AN3050-4	–	–	AN3054-4
1/4	–	AN3051-4	–	AN3054-6
1/4	–	–	AN3052-4	AN3054-8
3/8	AN3050-6	–	–	AN3054-6
3/8	–	AN3051-6	–	AN3054-8
3/8	–	–	AN3052-6	AN3054-10
1/2	AN3050-8	–	–	AN3054-8
1/2	–	AN3051-8	–	AN3054-10
1/2	–	–	AN3052-8	AN3054-12
5/8	AN3050-10	–	–	AN3054-10
5/8	–	AN3051-10	–	AN3054-12
5/8	–	–	AN3052-10	AN3054-16
3/4	AN3050-12	–	–	AN3054-12
3/4	–	AN3051-12	–	AN3054-16
3/4	–	–	AN3052-12	AN3054-20
1	AN3050-16	–	–	AN3054-16
1	–	AN3051-16	–	AN3054-20
1	–	–	AN3052-16	AN3054-24
1-1/4	AN3050-20	–	–	AN3054-20
1-1/4	–	AN3051-20	–	AN3054-24
1-1/4	–	–	AN3052-20	AN3054-28
1-1/2	AN3050-24	–	–	AN3054-24
1-1/2	–	AN3051-24	–	AN3054-28
1-1/2	–	–	AN3052-24	AN3054-32
1-3/4	AN3050-28	–	–	AN3054-28
1-3/4	–	AN3051-28	–	AN3054-32
1-3/4	–	–	AN3052-28	AN3054-40
2	AN3050-32	–	–	AN3054-32
2	–	AN3051-32	–	AN3054-40
2-1/2	AN3050-40	–	–	AN3054-40

TABLE 11-6

AN Fittings for Rubber Covered Aluminum (Type II) Flexible Metallic Conduit

Nominal Conduit Size	Regular Ferrule	One-Step Up Ferrule	Two-Step Up Ferrule	Nut
3/16	AN3050-3	-	-	AN3054-3
3/16	-	AN3051-3	-	AN3054-4
1/4	AN3050-4	-	-	AN3054-4
1/4	-	AN3051-4	-	AN3054-6
1/4	-	-	AN3052-4	AN3054-8
3/8	AN3050-6	-	-	AN3054-6
3/8	-	AN3051-6	-	AN3054-8
3/8	-	-	AN3052-6	AN3054-10
1/2	AN3050-8	-	-	AN3054-8
1/2	-	AN3051-8	-	AN3054-10
1/2	-	-	AN3052-8	AN3054-12
5/8	AN3050-10	-	-	AN3054-10
5/8	-	AN3051-10	-	AN3054-12
5/8	-	-	AN3052-10	AN3054-16
3/4	AN3050-12	-	-	AN3054-12
3/4	-	AN3051-12	-	AN3054-16
3/4	-	-	AN3052-12	AN3054-20
1	AN3050-16	-	-	AN3054-16
1	-	AN3048-16	-	AN3054-20
1	-	-	AN3083-16	AN3054-24
1-1/4	AN3050-20	-	-	AN3054-20
1-1/4	-	AN3048-20	-	AN3054-24
1-1/4	-	-	AN3038-20	AN3054-28
1-1/2	AN2050-24	-	-	AN3054-24
1-1/2	-	AN3048-24	-	AN3054-28
1-1/2	-	-	AN3083-24	AN3054-32
1-3/4	AN3050-28	-	-	AN3054-28
1-3/4	-	AN3048-28	-	AN3054-32
1-3/4	-	-	AN3083-28	AN3054-40
2	AN3050-32	-	-	AN3054-32
2	-	AN3048-32	-	AN3054-40
2-1/2	AN3050-40	-	-	AN3054-40

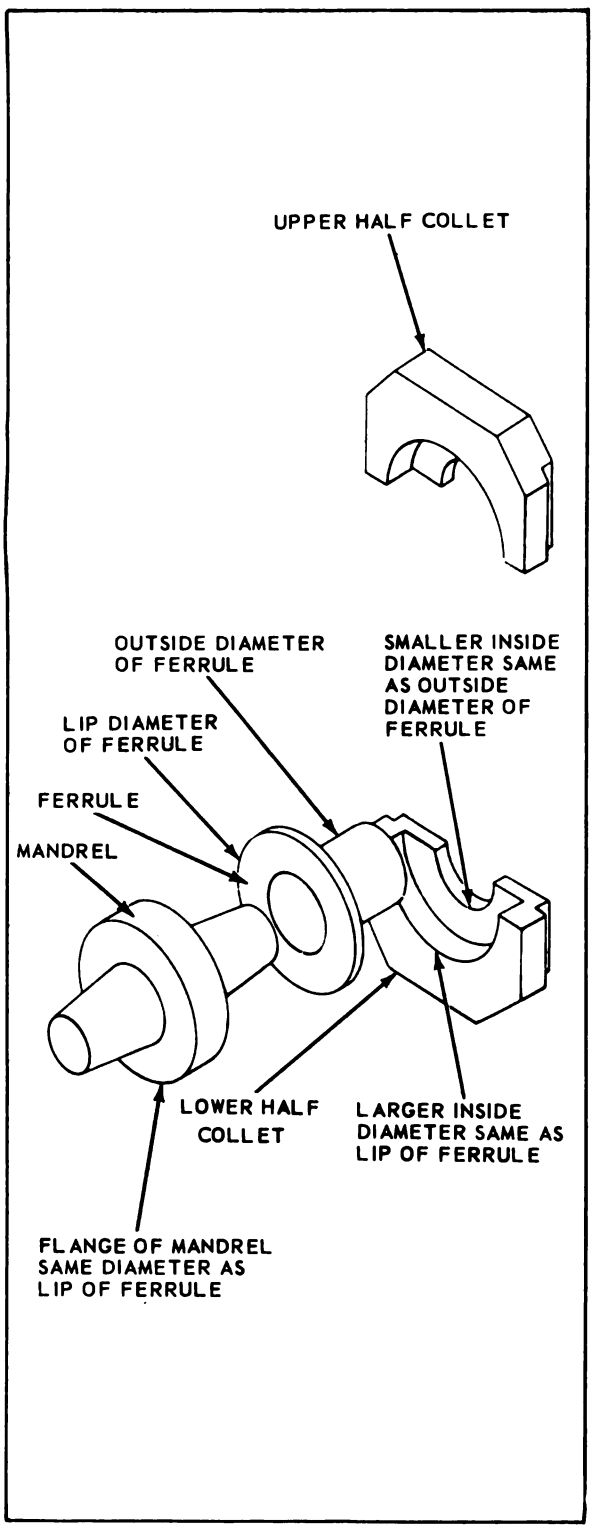


Figure 11–10. Mandrel and Collet for Amphenol Machine

11–15. PREPARATION AND USE OF AMPHENOL FERRULE ASSEMBLING MACHINE. Prepare and use ferrule assembling machine as follows:

a. Select mandrel with an OD that will allow ferrule being used to fit snugly on it, against the mandrel flange. Select a collet which will provide a snug fit on the ferrule lip. See figure 11–10.

b. Rotate mandrel wheel in direction shown by arrow until shaft is fully retracted as in figure 11–11.

c. Rotate adjustment screw in direction shown by arrow until beading rollers are fully retracted.

d. Place mandrel in shaft as in figure 11–12.

e. Drop lower half of collet in place.

f. Rotate mandrel wheel in direction shown by arrow until mandrel is in light contact with collet. (See figure 11–13)

g. Make sure that mandrel is seated in shaft, and tighten set screw with wrench as shown in figure 11–13.

h. Rotate mandrel wheel in opposite direction until mandrel is fully retracted.

i. Wash ferrule and nut in Stoddard's solvent to remove petrolatum, and dry thoroughly with air blast. Coat threads of nut with anti-seize compound (Military Specification JAN-A-669).

j. Slip nut on to conduit, and insert conduit end into ferrule until conduit bottoms, as shown in figures 11–14 and 11–15.

k. Rotate mandrel wheel in direction shown by arrow in figure 11–16a, to start mandrel forward, at the same time slipping conduit and ferrule assembly firmly onto mandrel. Drop upper half of collet into place, and continue rotation of mandrel wheel until ferrule is held firmly between mandrel flange and collet flanges. See figure 11–16b.

l. Turn adjustment screw (figure 11–17) clockwise until beading rollers exert slight pressure on ferrule.

m. Rotate crimping wheel back and forth, at the same time turn adjustment screw clockwise in four steps or until the desired depth of impression is achieved. See figure 11–18 for illustration of good ferrule crimp.

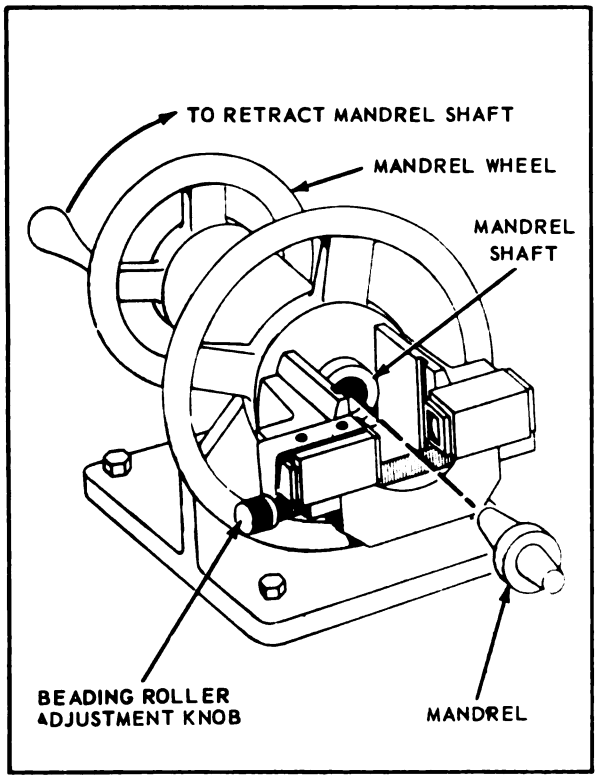


Figure 11–11. Retracting Mandrel Shaft

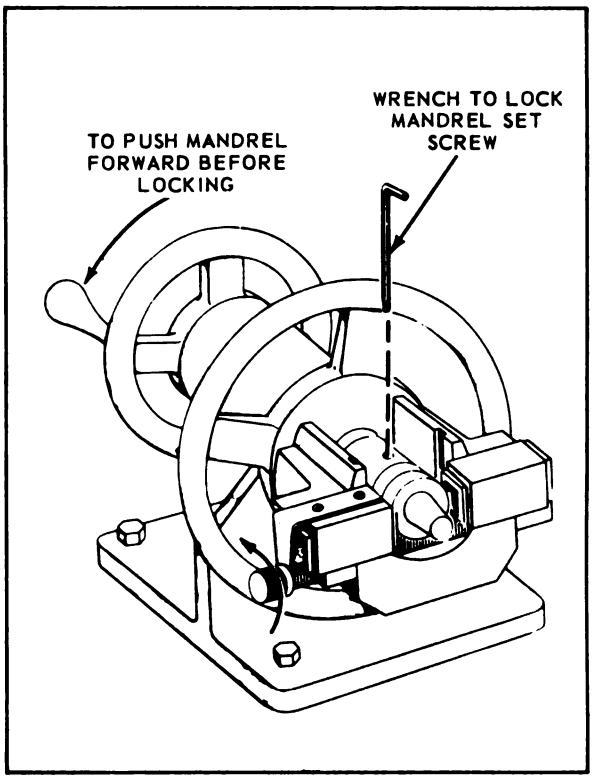


Figure 11–13. Locking Mandrel in Place

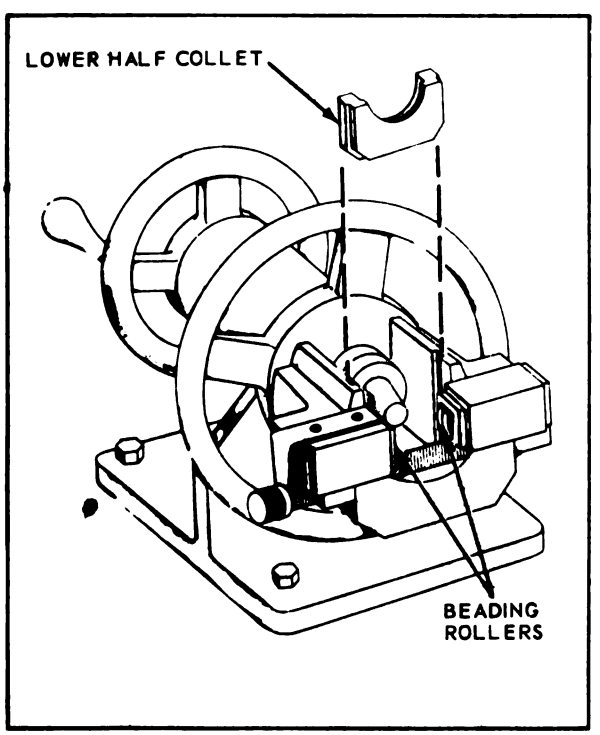


Figure 11–12. Installing Mandrel and Lower Half Collet

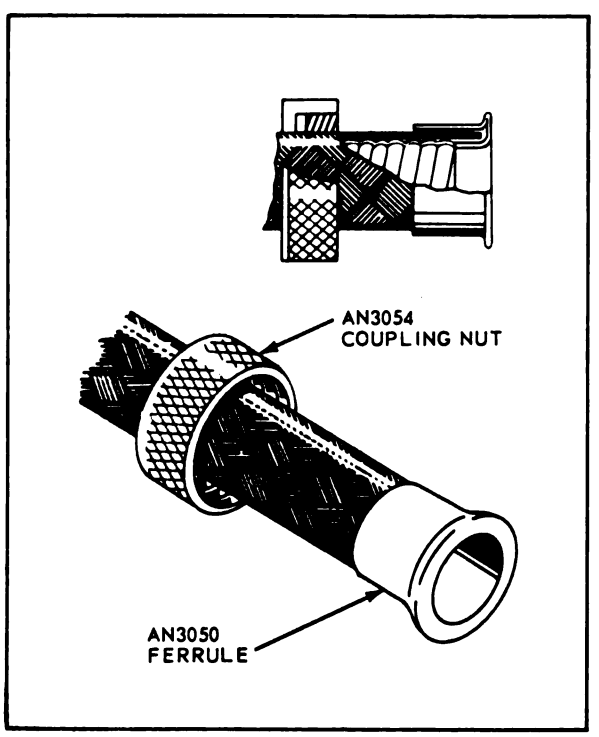


Figure 11–14. Bare Flexible Conduit Ready for Swaging

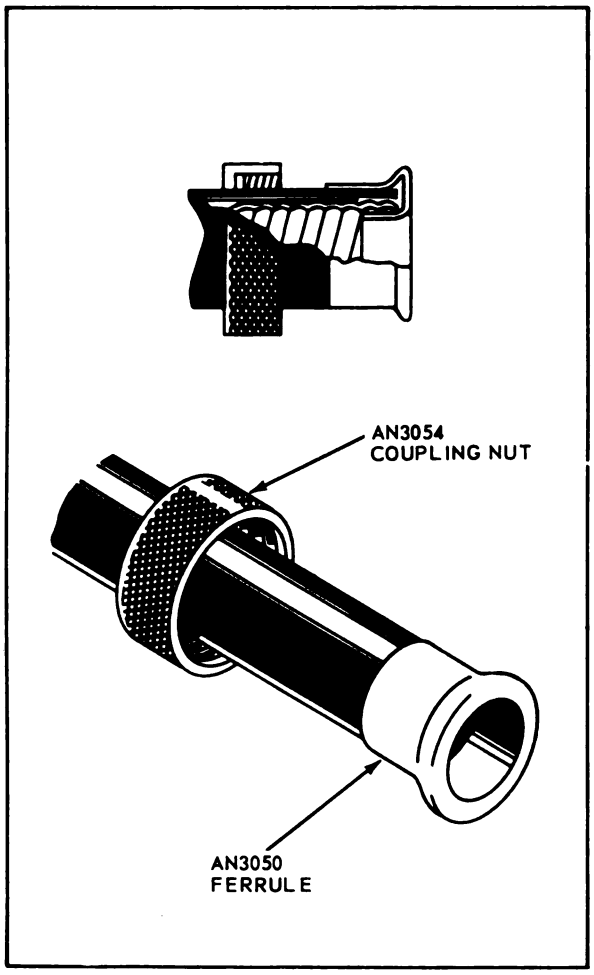


Figure 11–15. Rubber-Covered Flexible Conduit Ready for Swaging

CAUTION

Do not attempt to get full depth of crimp in one rotation as this will crack the aluminum ferrule. Watch beading closely during the operation, and stop rotation of crimping wheel when sufficient depth is reached.

n. Retract beading rollers fully.

o. Hold crimped conduit firmly, and retract mandrel fully.

p. Remove upper half of collet, and remove crimped conduit.

q. Test ferrule crimp by applying 50 pound pull test.

CAUTION

Hold conduit tight and square against ferrule during entire operation.

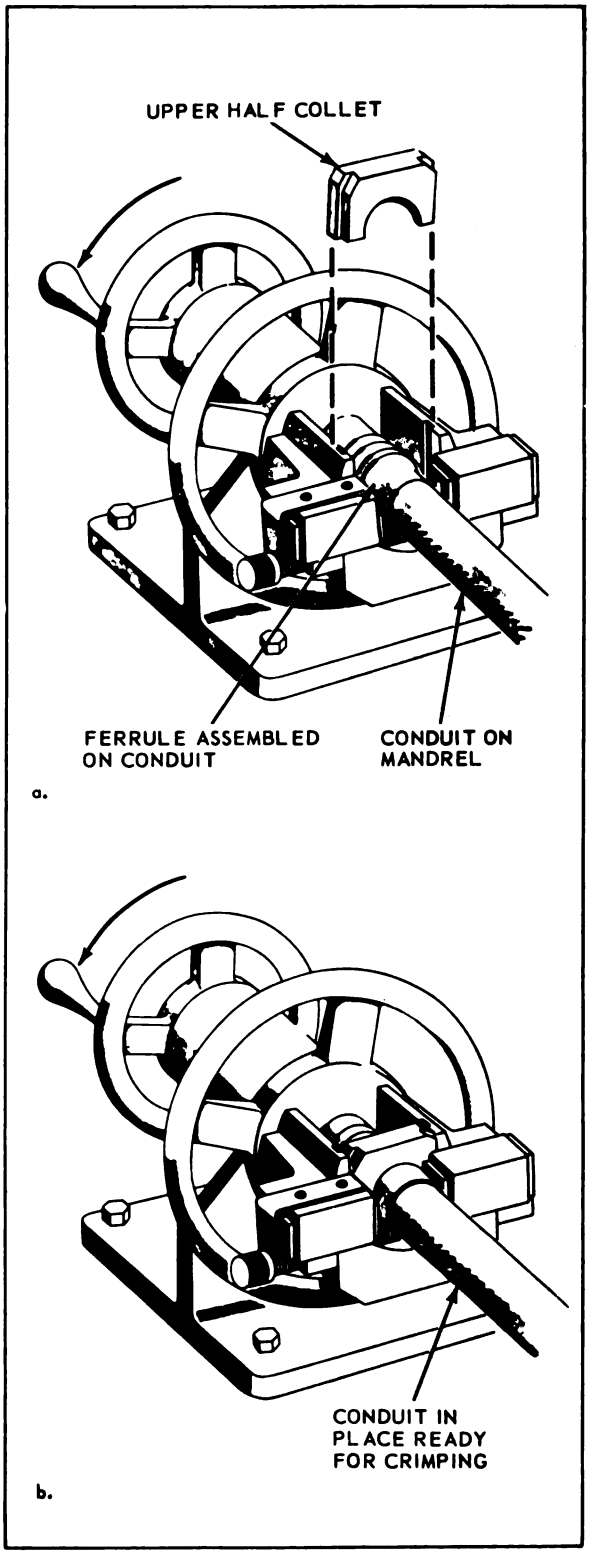


Figure 11–16. Placing Conduit Assembly in Machine

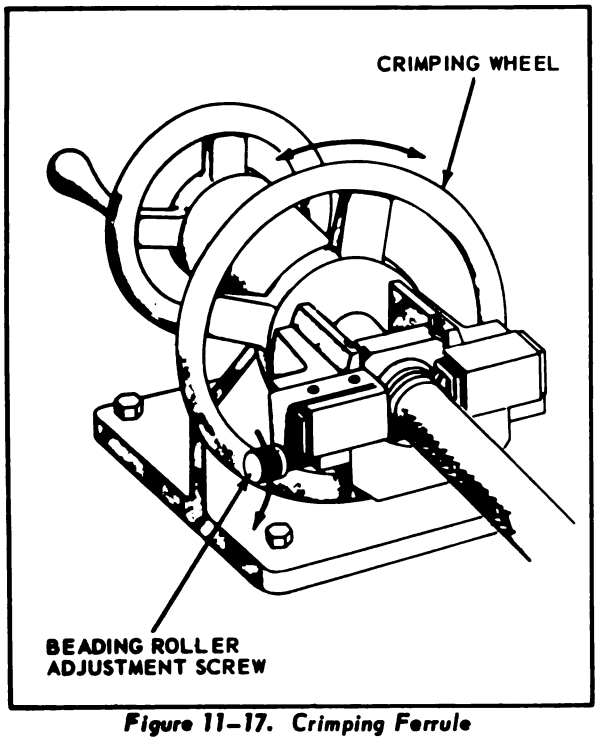


Figure 11–17. Crimping Ferrule

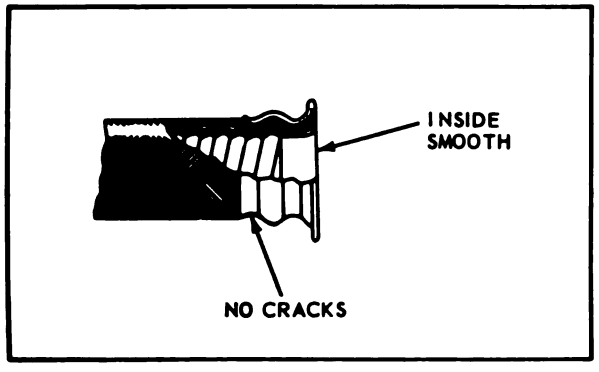


Figure 11–18. Good Crimped Ferrule

11–16. PREPARATION AND USE OF BREEZE MACHINE FOR FLEXIBLE ALUMINUM CONDUIT. Prepare and use the Breeze swaging machine as follows:

a. Place die shoe holder "A" in swaging machine as shown in figure 11–19. The countersunk portion should face swaging handle "B".

b. Fasten die shoe holder "A" in place by moving plates "C" over edges of die shoe holder. Tighten four screws in plates "C".

c. Select proper punch and die for the ferrule to be swaged from table 11–7.

d. Place die "D" in die shoe holder "A" and tighten in place with four screws "E". Oil inside surfaces of die.

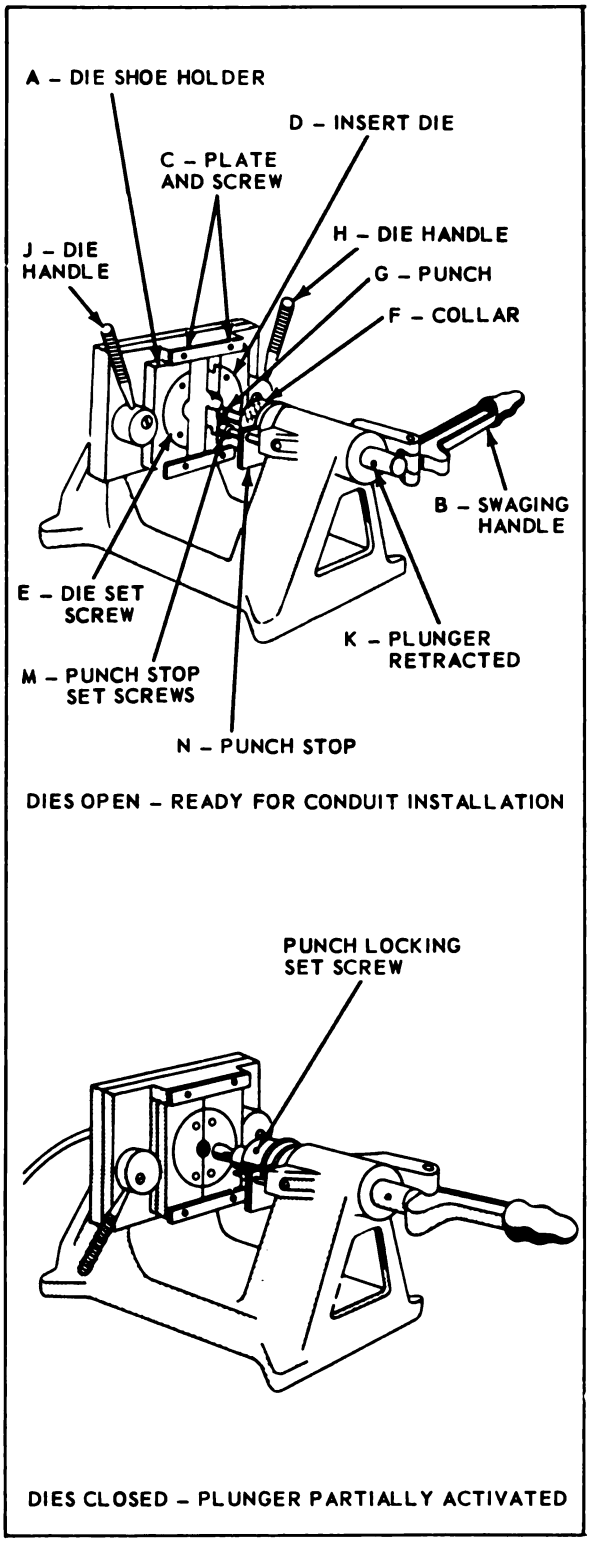


Figure 11–19. Breeze Ferrule Swaging Machine

TABLE 11–7

Accessories for Breeze Swaging Machine

Conduit	Machine Collar	Ferrule Punch	Ferrule die
3/16	–	17–13–0187	19–19–0187
1/4	4257–1–20	15–0250–110	19–19–0250
3/8	4257–1–20	15–0375–110	19–19–0375
1/2	4257–2–20	15–0500–120	19–19–0500
5/8	4257–2–20	15–0625–120	19–19–0625
3/4	4257–2–20	15–0750–120	19–19–0750
1	4257–3–20	15–1000–140	19–1000–40
1–1/4	4257–3–20	15–1250–140	19–1250–40
1–1/2	4257–3–20	15–1500–140	19–1500–40
1–3/4	4257–3–20	15–1750–150	19–1750–40
2	4257–3–20	15–2000–150	19–2000–40
2–1/2	4257–3–20	15–2500–150	19–2500–40

e. Place collar "F" over solid end of punch "G" so that collar flange will face swaging handle "B" when installed. Collar "F" has internal spring loaded pins which must enter holes in punch "G".

f. Install punch "G" and collar "F" on plunger "K". Collar flange must face swaging handle "B" end of machine. Use hex wrench through hole in collar to lock punch "G" in place in plunger "K". Machine is now ready for use. Prepare conduit assembly as follows:

g. Wash ferrule and nut in Stoddard's solvent to remove petrolatum, and dry thoroughly with air blast. Coat threads of nut with anti-sieze compound (Military Specification JAN-A-669).

h. Slide nut on conduit and insert conduit end into ferrule as far as it will go. See figure 11–14.

i. Place conduit with ferrule to be swaged in die "D". Pull die handles "H" and "J" down, clamping ferrule in position. Only 1/8" of ferrule should be inside die "D".

j. Rotate collar "F" so that internal spring loaded pins DO NOT line up with holes in punch. This will prevent the plunger "K" from expanding punch "G" during punch adjustment in next two steps.

k. Loosen punch limit screws "M" and pull gently on swaging handle "B" so that punch forces ferrule into die. Set punch limit screws so that punch "G" does not crush shoulder of ferrule against face of die "D".

l. Flange of collar "F" should now rest against rear (swaging handle end) of punch stop "N", preventing further forward travel of punch. The machine is now adjusted for repeated swaging operations on similar size ferrules.

m. Rotate collar "F" so that pins LINE UP with holes in punch. This cannot be seen but can be felt.

n. Pull handle "B" forward, expanding punch "G" inside of ferrule. This is the swaging operation. Repeat several times to obtain smooth surface inside ferrule.

o. Release swaging handle "B" and die handles "H" and "J" to remove conduit from machine.

p. Check inside diameter of ferrule to dimensions in table 11–8. If inside diameter is too small, repeat steps i and n. If inside diameter is too large, reject the assembly.

q. Test ferrule crimp by applying 50 pound pull test.

TABLE 11–8

Ferrule Diameter After Swaging

Conduit Size	ID of ferrule after swaging
3/16	.157
1/4	.220
3/8	.345
1/2	.470
5/8	.595
3/4	.720
1	.970
1–1/4	1.225
1–1/2	1.470
1–3/4	1.720
2	1.970
2–1/2	2.470

Note

The following steps (r through w) apply only when rubber covered conduit is being fabricated.

r. Remove dies "D", collar "F" and punch "G" from machine. Select new dies and punch to match conduit diameter from table 11–9. Install these parts in same manner as previous installations of dies and punch (refer to 11–16, steps d and f).

Note

The collar "F" is omitted from machine for the following operation.

s. Roll rubber cover of conduit back in place, and slide conduit collar into position as shown in figure 11–20. Temporarily insert 1/32 inch spacer between conduit collar and back of nut.

t. Fit conduit into machine so that conduit collar fits into cutout in dies "D".

u. Close die handles "H" and "J".

v. Pull swaging handle "B" to swage conduit collar onto conduit.

w. Remove temporary spacer and examine clearance between nut and collar. Use a knife to remove any rubber extruded from under collar.

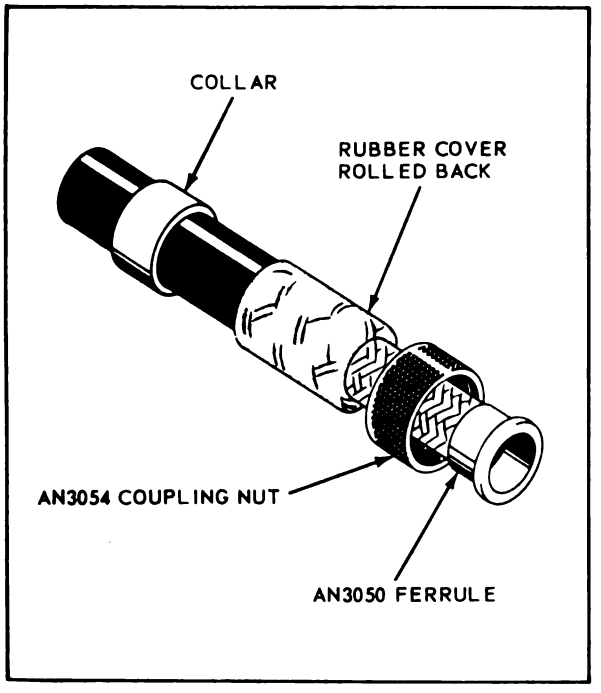


Figure 11–20. Rubber Covered Conduit Prepared for Breeze Machine

TABLE 11–9

Collar Punches and Dies for Breeze Swaging Machine

Nominal Conduit Size	Collar Punch	Collar Die
3/16	18–3–187	19–8–187
1/4	18–3–250	19–8–250
3/8	18–3–375	19–8–375
1/2	18–3–500	19–8–500
5/8	18–3–625	19–8–625
3/4	18–3–750	19–8–750
1	18–3–1000	19–8–1000
1–1/4	18–3–1250	19–8–1250
1–1/2	18–3–1500	19–8–1500

11–17. SELECTION OF FITTINGS FOR FLEXIBLE BRASS CONDUIT. Select ferrule and nut for bare flexible brass conduit from table 11–10. Use the same ferrule and nut for rubber covered brass conduit, and add conduit collar of appropriate size. Use the Military Standard fittings listed in table 11–10 when possible. If these are not available in the required size, use the commercial fitting listed in the table.

11–18. FABRICATION OF FLEXIBLE BRASS CONDUIT. Refer to figures 11–19 through 11–21. Fabricate flexible brass conduit, using Breeze swaging machine, as follows:

a. Dip ferrule and nut, (and collar, when rubber covered brass conduit is being used), in Stoddard's solvent to remove petrolatum. Dry thoroughly with air blast.

b. Tin rear half of ferrule, using rosin-alcohol flux and 50/50 tin-lead solder. Use solder pot for this operation.

c. Slip nut onto conduit and insert pre-tinned conduit end into ferrule until conduit bottoms.

d. Swage ferrule to conduit following instructions listed in 11–16, steps a through q.

e. Solder ferrule to conduit with electrical resistance unit as shown in figure 11–22, using rosin core 60/40 tin-lead solder. Fill with solder until there are no blow holes between ferrule and conduit, and the exterior is smooth.

f. Lubricate threads of nut with Military Specification JAN-A-669, anti-seize compound. When rubber-covered brass conduit is being fabricated, swage collar to conduit as instructed in 11–16, steps r through w.

11–19. NON-METALLIC CONDUIT.

11–20. GENERAL. Nonmetallic conduit is made of flexible plastic tubing, conforming to Military Specifications MIL-I-631 or MIL-I-7444. There is no Government specification for rigid non-metallic conduit; phenolic tubing is sometimes used.

TABLE 11-10

Fittings for Flexible Brass Conduit

Nominal Conduit Size	Regular Ferrule MS Number	Regular Ferrule Breeze No.	One Step Ferrule	Two Step Ferrule	Nut MS Number	Nut Breeze No.	Collar for Rubber Covered Conduit
3/16	MS25065-3	11-1-B3	11-2-B3	11-3-B3	MS25066-10	118-22-B3 118-22-B4 118-22-B6	117-3-B0187
1/4	MS25065-4	11-1-B4	11-2-B4	11-3-B4	MS25066-11	118-22-B4 118-22-B6 118-22-B8	117-3-B0250
5/16	MS25065-5	–	–	–	MS25066-12	–	–
3/8	MS25065-6	11-1-B6	11-2-B6	11-3-B6	MS25066-14	118-22-B6 118-22-B8 118-22-B10	117-3-B0375
1/2	MS25065-8	11-1-B8	11-2-B8	11-3-B8	MS25066-16	118-22-B8 118-22-B10 118-22-B12	117-3-B0500
5/8	MS25065-10	11-1-B10	11-2-B10	11-3-B10	MS25066-19	118-22-B10 118-22-B12 118-22-B16	117-3-B0625
3/4	MS25065-12	11-1-B12	11-2-B12	11-3-B12	MS25066-23	118-22-B12 118-22-B16 118-22-B20	117-3-B0750
1	MS25065-16	11-1-B16	11-2-B16	11-3-B16	MS25066-26	118-22-B16 118-22-B20 118-22-B24	117-3-B1000
1-1/8	MS25065-1o	–	–	–	MS25066-30	–	–
1-1/4	–	11-1-B20	11-2-B20	11-3-B20	–	118-22-B20 118-22-B24 118-22-B28	117-3-B1250
1-3/8	MS25065-22	–	–	–	MS25066-31	–	–
1-1/2	–	11-1-B24	11-2-B24	11-3-B24	–	118-22-B24 118-22-B28 118-22-B32	117-3-B1500
1-3/4	–	11-1-B28	11-2-B28	11-3-B28	–	118-22-B28 118-22-B32 118-22-B40	
2	–	11-1-B32	11-2-B32		–	118-22-B32 118-22-B40	117-3-B2000
2-1/2	–	11-1-B40			–	118-22-B40	117-3-B2500

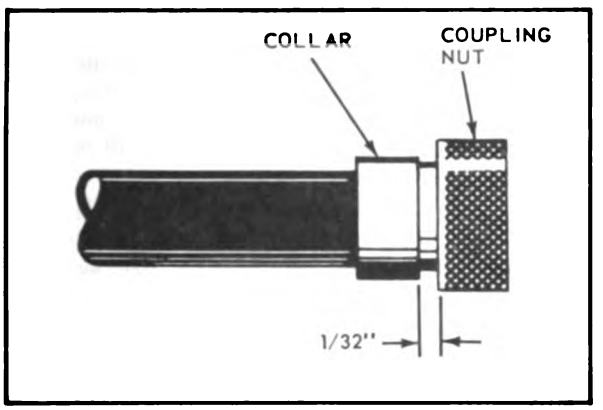


Figure 11–21. Final Position of Collar on Rubber Covered Conduit

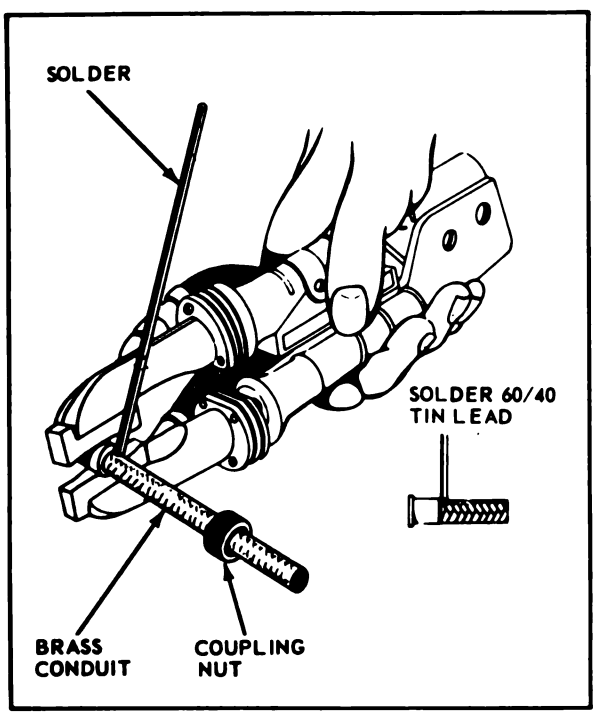


Figure 11–22. Soldering Ferrule to Brass Conduit

CAUTION

Use non-metallic conduit ONLY in areas where the ambient temperature is less than 200°F

11–21. FABRICATION OF NON-METALLIC CONDUIT USING TWO-PIECE FERRULES. Fabricate non-metallic conduit with two-piece ferrules as follows:

a. Cut plastic tubing to required length.

b. Slip an AN 3054 Nut and the female ferrule over conduit.

c. Insert male ferrule into conduit end.

d. Move female ferrule toward end of conduit over male ferrule, until the ferrule flanges are a maximum of 1/32 inch apart as shown in figure 11–23.

e. Lubricate threads of nut with Military Specification JAN-A-669, anti-seize compound. This completes the fabrication prior to assembly to mating equipment.

Note

During assembly to mating equipment, the tightening of the nut to the equipment will lock the ferrule onto the flexible conduit.

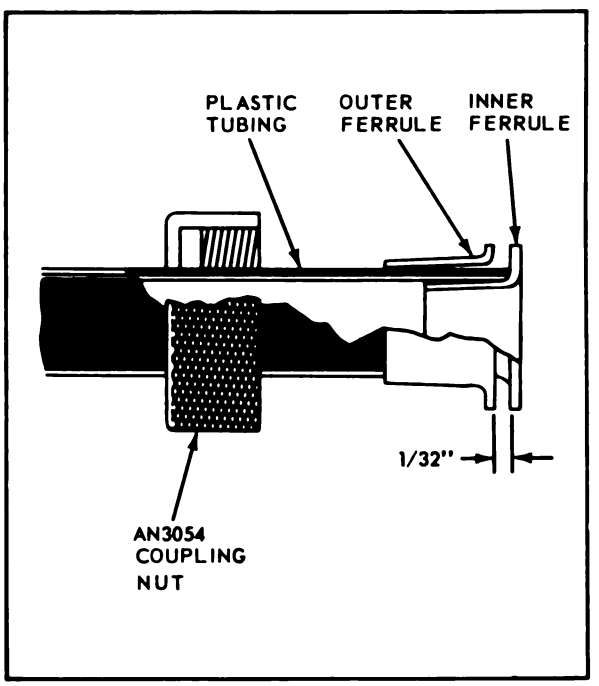


Figure 11–23. Installing Two-Piece Ferrule On Non-Metallic Conduit

11–22. USE OF HEAT-SHRINKABLE TUBING. Polyethylene tubing, which is shrunk to the desired size by the application of dry heat, may be used to protect single wires or wire groups where they break out from wire bundles or harnesses. The installation procedure is as follows:

a. Select from table 11–11 tubing of an ID that can be slipped easily over the wire or wire group.

b. Use a hot-air gun (see figure 11–24), hair dryer or other suitable method as a heat source. Hold the heat source four to five inches away from the wire, and apply a heat of 275°F to 300°F for approximately 30 seconds. Rotate the wire while applying the heat, so that the heat is evenly distributed.

c. Remove the heat as soon as the tubing forms to the shape of the wire, and allow to cool for approximately 30 seconds before handling.

TABLE 11–11

Sizes of Heat-Shrinkable Tubing

Sleeve Size (Thermofit)	Expanded ID (inches) As supplied Minimum	Recovered ID (inches) After Heating Maximum
24	.050	.027
22	.055	.032
20	.060	.039
18	.076	.049
16	.093	.061
14	.120	.072
12	.153	.089
10	.191	.112
8	.240	.141
6	.302	.178
4	.348	.224
2	.375	.275
5/16 in.	.413	.334
3/8 in.	.484	.399
7/16 in.	.578	.462
1/2 in.	.671	.524
5/8 in.	.843	.655
3/4 in.	1.000	.786
7/8 in.	1.187	.911
1 in.	1.335	1.036
1–1/4 in.	1.670	1.290
1–1/2 in.	2.000	1.550
1–3/4 in.	2.335	1.812
2 in.	2.670	2.070

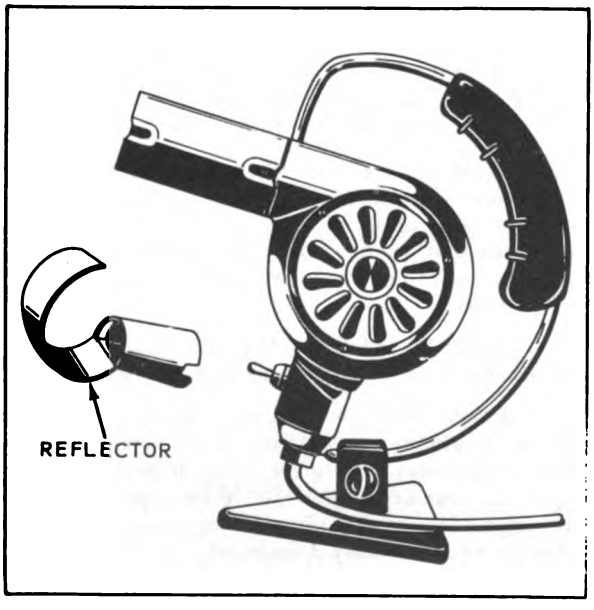


Figure 11–24. Electric Hot-Air Gun

CAUTION

Do not apply heat higher than 300°F as this may damage the wire. Do not continue to apply heat after the tubing has shrunk onto the wire; further application of heat will not cause it to shrink further.

d. If the tubing does not shrink onto the wire in approximately 30 seconds the tubing selected is probably too large. Select the next smallest size, and repeat the procedure.

SECTION XII

SPECIAL ELECTRICAL WIRING HARNESSES

12–1. INTRODUCTION.

12–2. GENERAL. Most of the interconnecting electrical wiring in military aircraft is in the form of open wire bundles as described in section XIV (refer to 14–4). In areas where it is necessary to protect the wiring against various types of damage, wire bundles are enclosed in conduit. However, because of the weight factor, extensive use of conduit is not desirable. Hook-up wire is sometimes used as inter-connecting wire to save weight and space, but this is permitted only when the hook-up wire is properly protected in a jacketed harness. In order to take advantage of the weight and space saving properties of hook-up wire, special protectively encased harnesses are used. These harnesses are predesigned and prefabricated for installation in specific predetermined locations in the airframe, and are installed or replaced as a single unit.

12–3. SCOPE. This section describes the appearance, fabrication, installation, repair and special features of two wiring harnesses. These are:

a. A rigid molded prefabricated harness used in the electrical wiring system of F8 airplanes.

b. A compact jacketed wire bundle used in the electrical wiring system of F4 airplanes.

12–4. MOLDED HARD HARNESS

12–5. GENERAL. The molded hard harness wiring system is a prefabricated, self-contained wire and plastic duct assembly. It is used to interconnect electrical and electronic equipment areas in a specific aircraft. It was developed to produce a compact harness, resistive to chafing, bending and mechanical damage. Its use is confined to electrically protected wiring only, and to those wires which may be combined with others, as in a conventional wire group or bundle. Thermocouple wires and coaxial cables are not included in molded hard harnesses.

Physically, molded harnesses are treated as structural elements and their fabrication and installation are covered by the structural drawings for a specific aircraft. Electrically the compacted wires are detailed in the aircraft manufacturer's Hard Harness Usage Charts for the specific aircraft. Each of these charts is a coded wiring diagram for a particular hard harness assembly.

12–6. REFERENCE SPECIFICATIONS.

CVA 11-1	Fabrication and Installation of Fiberglass Molded Wiring Harness
MIL-W-16878	Wire, Electrical, Insulated, High Temperature

12–7. DESCRIPTION.

12–8. MOLDED HARD HARNESS WIRING SYSTEM. Each complete system is made up of the separate hard harness assemblies detailed in the Harness Usage Charts. See figure 12–1 for a typical Harness Usage Chart.

12–9. MOLDED HARD HARNESS ASSEMBLIES. Each assembly consists of one or more rigid molded sections, combined with flexible sections. (See figure 12–2). The harness assembly configuration is determined by the design for a given aircraft and the routing prescribed to interconnect the applicable equipment areas within that airframe. Hard harness assemblies are semi-permanently coupled by taper pin block connectors, and conventional connectors are used at area breakouts and terminations. Connection to the individual area equipments is made direct from these conventional terminations (and breakout connectors), by means of conventional harness.

Note

Taper pin installation is described in section VI. Connection of wires to Standard MS connectors is described in section III, and to solderless terminal lugs in section V.

The harness wiring system is broken up into separate assemblies for the following reasons:

a. To facilitate molding.

b. To eliminate unwieldy lengths at installations.

c. To provide for inclusion of sealed connections at pressurized bulkheads.

d. To afford a conditional electrical isolation of assemblies for fault tests.

e. To facilitate repairs by replacement with a spare assembly.

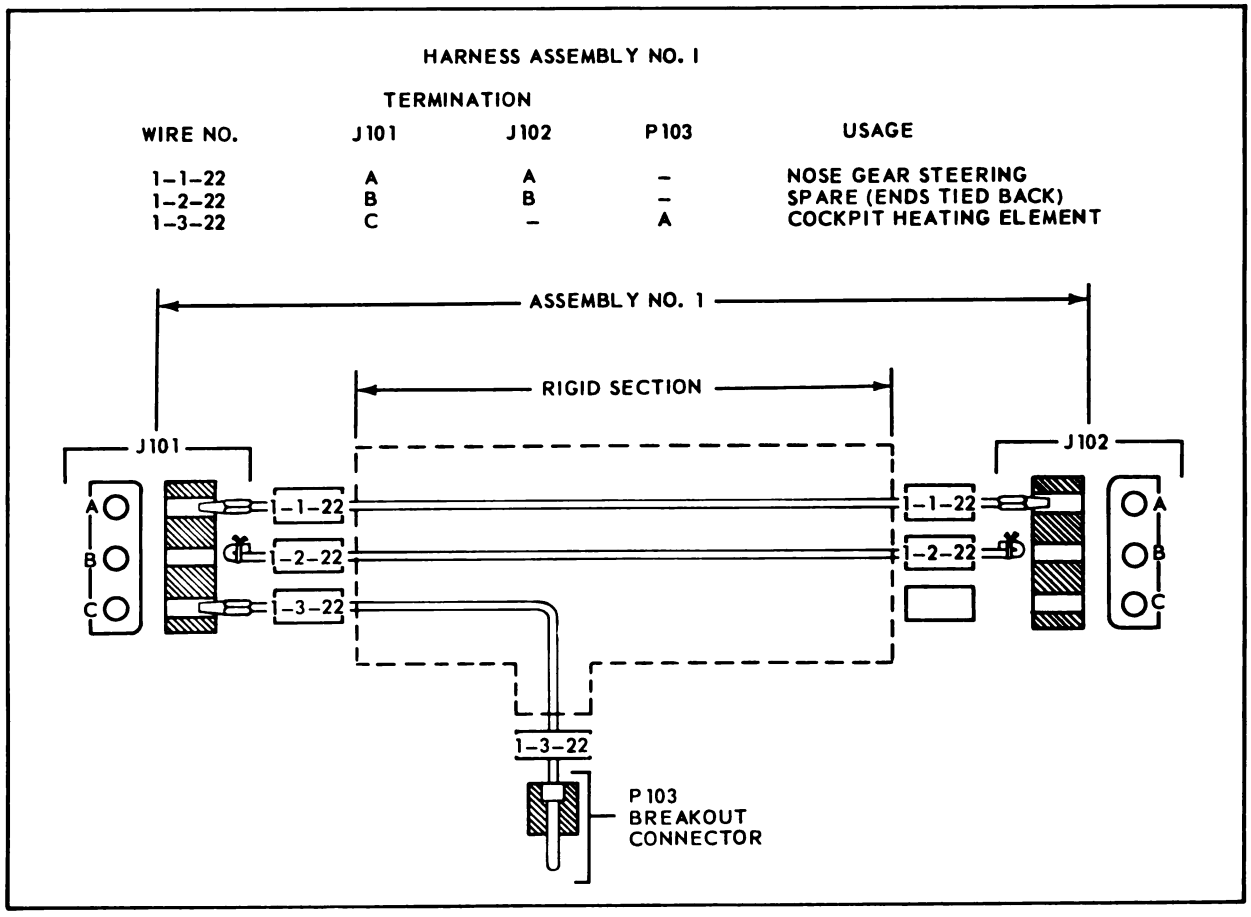


Figure 12–1. Example of Harness Usage Chart

Note

Because taper pin block connectors of hard harness assemblies are used to couple assemblies as installed into the air frame, they frequently occur in relatively inaccessible locations. These connectors are not normally meant to be used as test points. They should be unmated only for replacement of harness assembly. Use of these connectors to localize electrical faults should be resorted to only when there is no other alternative.

12–10. RIGID SECTIONS. The rigid, molded sections consist of a prefabricated embedment of specified wires and cables in a reinforced plastic encasement. (See figure 12–3). These are produced under pressure in special molds. (See figure 12–4.) Potting compound is used locally where the encased wires emerge from a molded section. The finished product is light in weight, compact and opaque. Within the aircraft, the hard harness assemblies are installed by means of clamps around the rigid sections. These fix the assembly to the structure as required by the structural drawings.

12–11. FLEXIBLE SECTIONS. Flexible sections are used at terminations, breakouts, or between the rigid sections of an assembly. They consist of an uncased length of continuous wires (all coded) and are protected by zipper tubing. Flexible sections are used for the following reasons:

a. To allow installation of an assembly where difficult fits are involved.

b. To make up mating tolerance.

c. To allow for flexing of the airframe.

12–12. SPARE WIRES IN HARD HARNESS. At least 10 per cent spare wires are included in each harness. In the through wires between harness coupling or taper pin block connectors the spares are cut and tied back, (no dead end protection). (See figure 12–1.) Spare block pins are provided to utilize spares as needed. At area breakouts or terminations, the spares are attached to the connector contacts in the same way as active wires are attached. They are then ready for instant use when the dead ends are activated at coupling connections. Spares are to be used for future aircraft service changes *only* and not for repair.

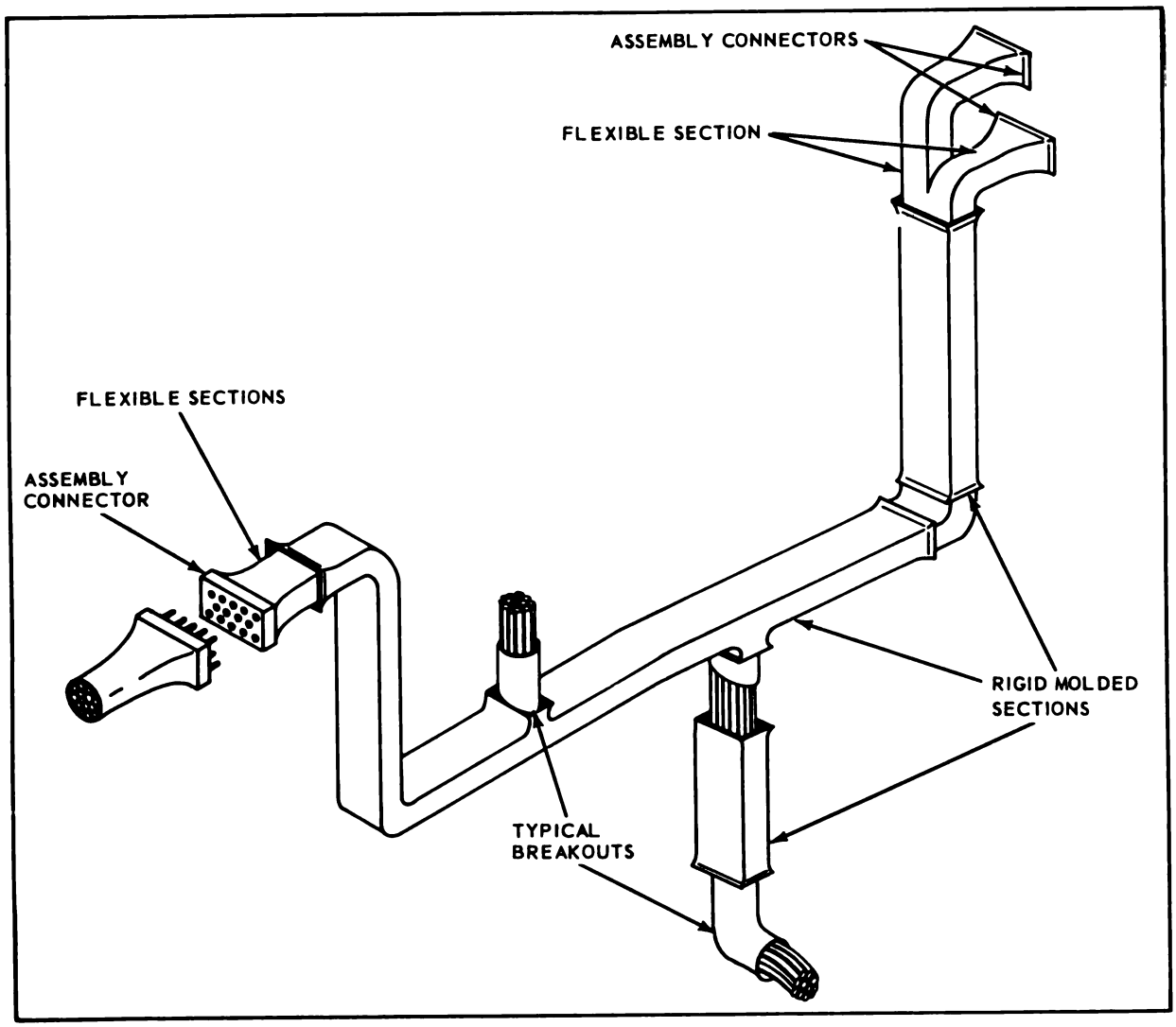


Figure 12–2. Typical Molded Hard Harness Assembly

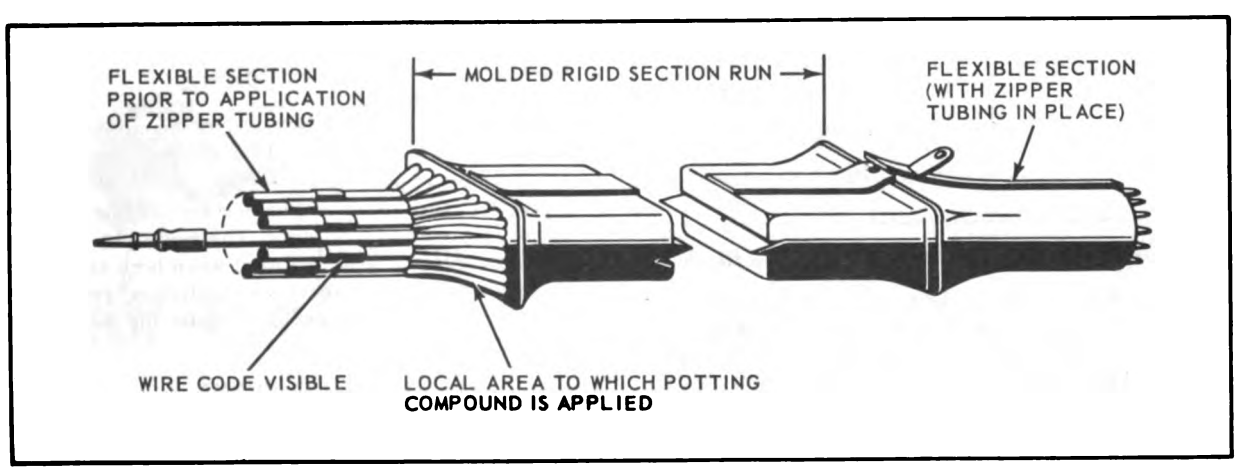


Figure 12–3. Typical Rigid Section

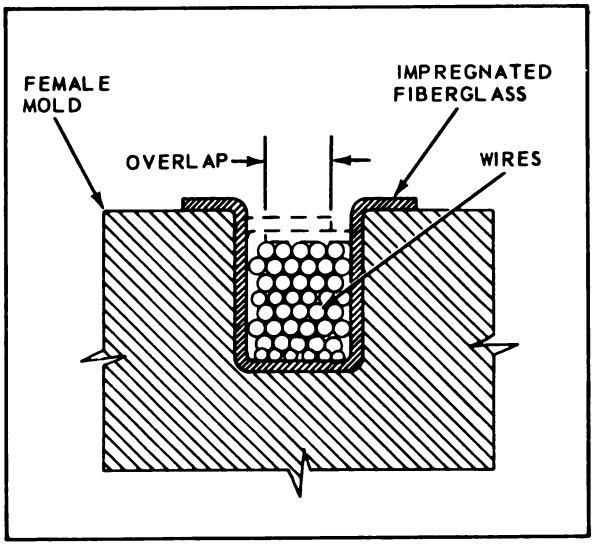


Figure 12–4. Typical Cross Section

Note

Each exposed end of a spare wire is identified at the harness assembly connection by the applicable Harness Usage Chart wire code identification number.

12–13. IDENTIFICATION OF HARD HARNESS WIRES AND CONNECTIONS. Each individual wire in a hard harness assembly is identified at the terminations only by means of a sleeve marked with the wire code; this consists of a harness code number, the individual wire number and the gage size of the individual wire, as shown in figure 12–5. The Hard Harness Usage Chart codes all electrical details of a harness assembly under the three headings of wire number, termination and usage. See figure 12–1. The first group, that of the

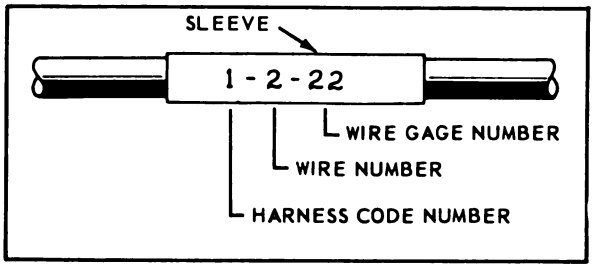


Figure 12–5. Typical Wire Identification Number

wire number, is as marked on the individual wires. The first entry indicates that in Harness Assembly, #1, wire #1 is 22 gage; that its terminations are at pin A of receptacle J101 and pin A of receptacle J102; and that it serves the nose steering gear area. The second entry is similar to the first except for its being a spare. In the third entry a breakout is indicated.

Note

The wire number code identification 1-2-22 is marked on the exposed, tied back end at J101 and at the connection to pin "B" of P102. This wire can be selected and activated by using the appropriate contact of mating plugs, pins B of plugs P101 and P102.

12–14. INSTALLATION OF MOLDED HARD HARNESS ASSEMBLY. Molded hard harness assemblies are installed according to the applicable structural diagrams, both for location and method of attachment to structure.

CAUTION

During installation care must be taken to prevent drilling into or damaging any part of a hard harness assembly.

12–15. EMERGENCY REPAIRS. In the event of shorts, opens, burnouts, etc. of a hard harness wire, the mating wire in the conventional area harness is cut behind the connector. It is then spliced to a length of wire which is run next to the hard harness (outside the harness) and through the hard harness clamp. At the opposite end the first step is repeated with the other conventional harness. If the wire must go through a solid bulkhead, approval must be obtained to drill the bulkhead, and install a grommet.

CAUTION

This method is for emergency use only. The complete harness assembly must be replaced as soon as possible.

12–16. PERMANENT REPAIRS. Replacement harnesses are supplied without terminations, to avoid damage to terminations during shipment and handling. Appropriate terminations, as specified on applicable drawings, are attached during installation.

12–17. COMPACT WIRE BUNDLES.

12–18 GENERAL. Compact wire bundles are those wire bundles which are fabricated from hook-up wire and therefore require a braided outer jacket for abrasion protection. Compact wire bundles are confined to electrically protected wiring only. Thermocouple wires and coaxial cables may be included when both ends of the wires or cables terminate in multi-pin connectors. Spare wires are not enclosed under the main bundle braided jacket.

12–19. REFERENCE DOCUMENT.
NAVWEPS 01-245FDB-2-10.2. Maintenance Instructions Manual – Navy Model F-4B (F4H-1) Aircraft - Wiring Repair Data.

12–20. DESCRIPTION. The wire bundle is prefabricated (without terminations) of wires twisted together in one or more lays, each lay twisted in the opposite direction to the preceding lay. The wire bundle is completely covered with a braided dacron protective jacket which ends approximately three inches from the termination points. When the wire bundle is installed, and the terminations attached, the exposed area between the end of the braided jacket and a connector is covered with a protective boot. (See figure 12–6.) When splice terminations are used the splice area is protected by heat-shrinkable silicone sleeving. (See figure 12–7.)

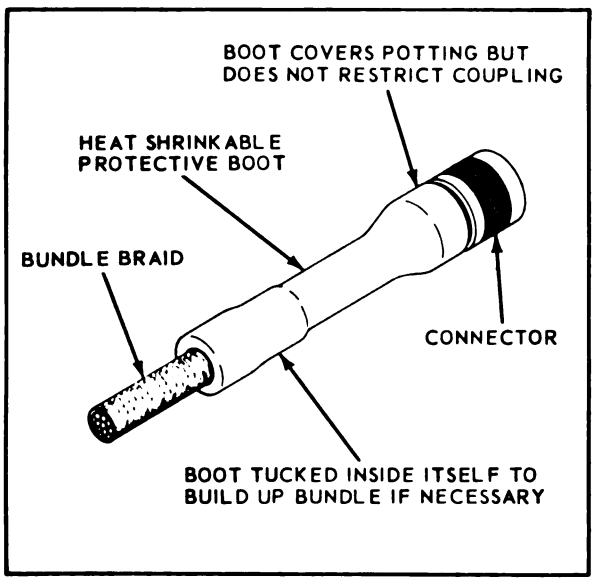


Figure 12–6. Protective Boot on Compact Wire Bundle

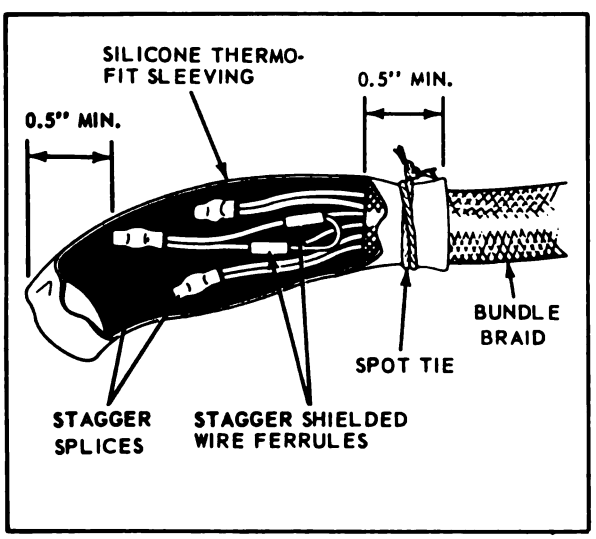


Figure 12–7. Heat-Shrinkable Sleeving Over Splice Area

12–21. IDENTIFICATION. Each compact wire bundle is marked with the bundle number. Each wire in the bundle is identified at its termination points by means of a sleeve marked with the wire identification code (refer to section II). Individual wires in the bundle are not identified under the jacket braid. The manual referenced in 12–19 includes complete information (wire bundle data) on each compact wire bundle installed in F4H-1 aircraft. The wire bundle data consists of the following:

a. A dimensional layout. (See figures 12–8 and 12–9). The drawing title of each layout indicates the airplane area in which the wire bundle is installed, the individual airplane code number, and the bundle number within the area.

b. A parts list. This lists the quantity, name and part number of each component in a specific wire bundle, with the exception of the braided outer jacket.

c. A wire table. This lists the wire number, the Military Specification number for the wire, its length (in inches) and its terminations.

12–22. TYPES OF REWORK. The following types of rework and repair peculiar to compact wire bundles are fully described and illustrated in the Maintenance Instructions Manual referenced in 12–9:

a. Removal and installation of protective boots. These boots are used on the exposed wire access area between the rear of a potted connector and the end of the braided bundle jacket. (See figure 12–10).

b. Removal and repair of bundle braid. This procedure is required to make wire modifications and for the inspection of wire damage under the braid.

c. Heat shrinking process for thermofit sleeving. Heat-shrinkable sleeving is used to replace protective boots, at splice areas (see figure 12–7), and for insulating end caps. Refer to Section XI, paragraph 11–22 for selecting and installing heat-shrinkable tubing.

d. Assembly of stub splices and covering stub splice areas. Stub splices are defined as those splices that enter the wire connector from the same end. (Refer to figure 12–7).

e. Assembly of parallel butt splices. Butt splices enter the wire connector from both ends.

f. Shield termination. Includes both grounded and ungrounded shield terminations. Refer to Section II, paragraphs 2–56 through 2–68 for shield terminations.

g. Wire re-identification. This procedure covers changing or replacing identification sleeves when the wire need not be severed. Refer to Section II, paragraphs 2–21, 2–26 and 2–32 through 2–35 for wire identification sleeves.

h. Adding wires to compact wire bundles.

i. Replacing wires in compact wire bundles.

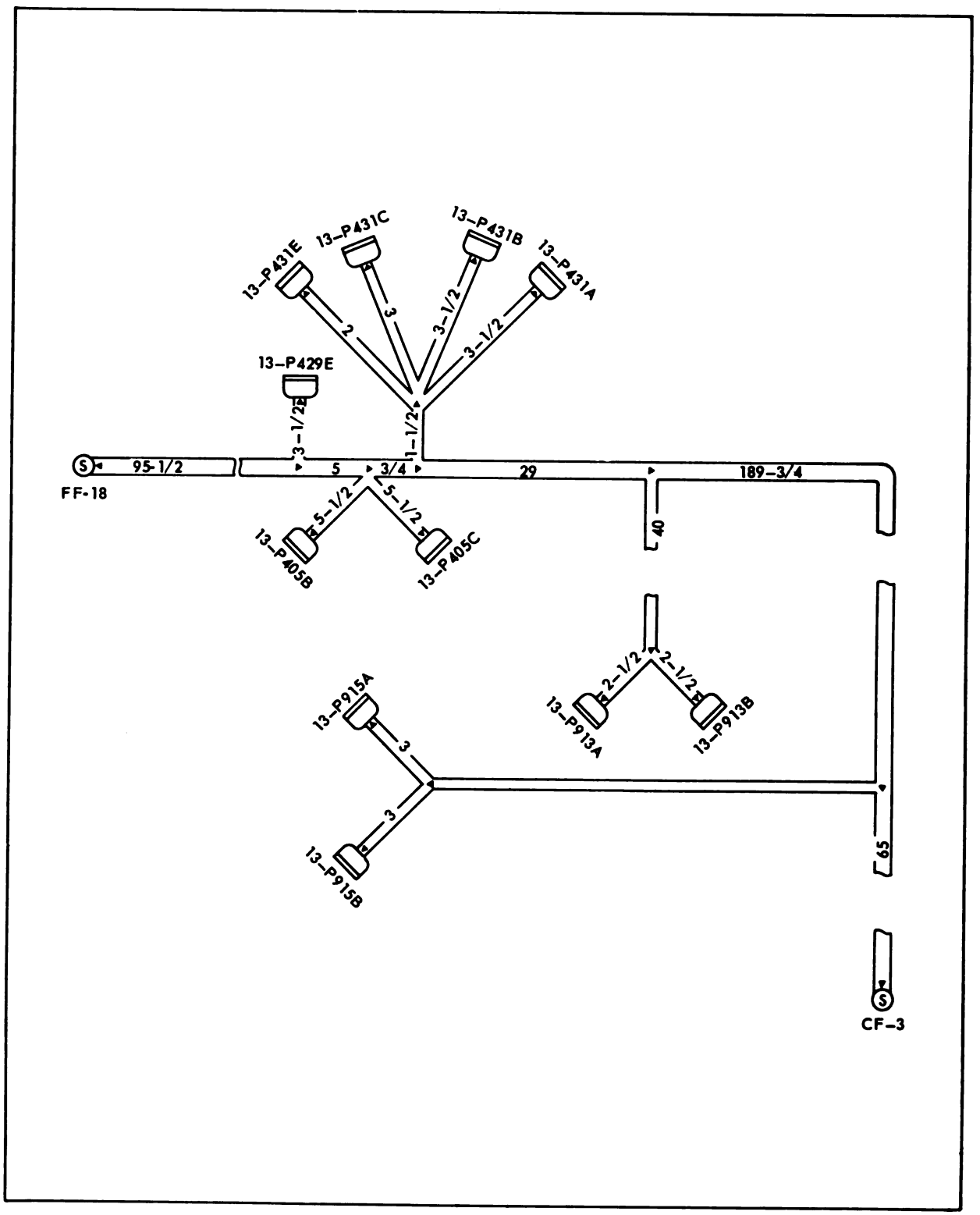


Figure 12–8. Typical Dimensional Layout

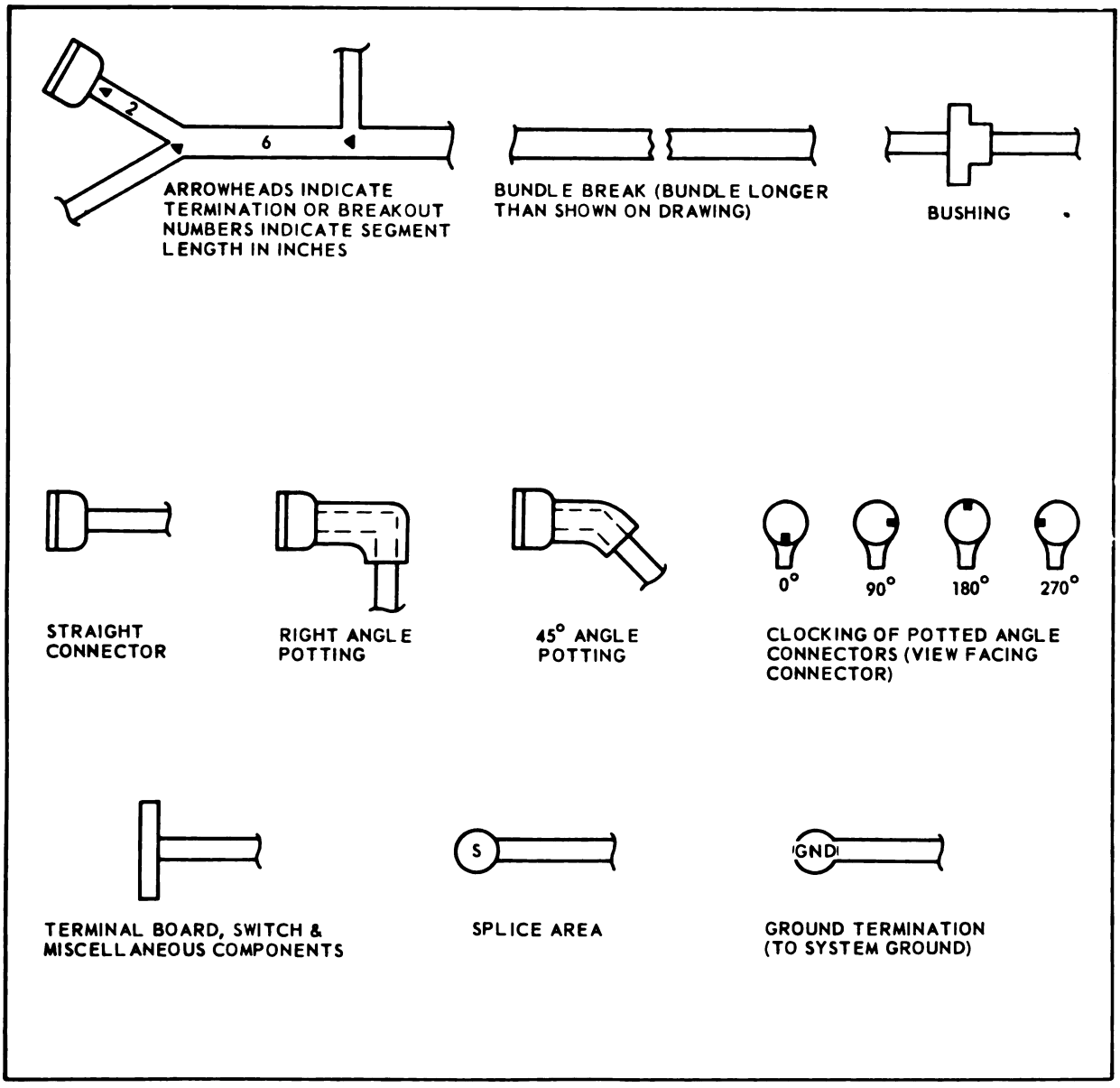


Figure 12–9. Dimensional Layout Symbols

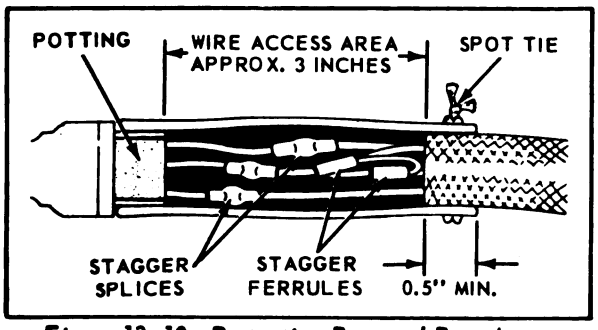


Figure 12–10. Protective Boot and Boot Area

j. Removing wires from compact wire bundles.

k. Treating TFE insulated wire to obtain a bondable surface. Refer to Section X, paragraph 10–20 for TFE treating.

l. Repair of wire damaged under bundle braid.

m. Removal and installation of high temperature potting at rear of connection. Refer to Section XIX for potting repairs.

SECTION XIII

INSTALLATION OF BUSBARS, CONDUIT JUNCTION BOXES, PROTECTIVE DEVICES AND TERMINAL BOARDS

13–1. INTRODUCTION.

13–2. PURPOSE. Procedures for installing equipment in aircraft are recommended in order to make installation easier, to standardize the methods used, and to provide the best possible protection for personnel and equipment.

13–3. SCOPE. This section describes the recommended procedures for installing busbars (including preparation), conduit, junction boxes, protective devices and terminal boards in aircraft. It also describes methods of identification and protection and the correct use of hardware.

13–4. REFERENCE SPECIFICATIONS AND DRAWINGS.

MIL-I-631	Insulation, Electrical, Synthtic Resin
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-C-6136	Conduit, Flexible, Shielded Aluminum Alloy
MIL-E-7080	Electrical Equipment; Installation of, Aircraft, General Specification
MIL-I-7444	Insulation Sleeving, Electrical, Flexible
MIL-C-7931	Conduit, Electrical, Flexible, Radio Frequency Shielding
MS25123	Terminal Board, Electrical, Assembly of
MS27212	Terminal Board Assembly, Molded-In Stud, Electrical
AND 10380	Fitting Installations, Standard AN Conduit
AND 10449	Circuit Breaker Installation

13–5. PREPARATION AND INSTALLATION OF BUSBARS.

13–6. GENERAL. Busbars are used in aircraft for power distribution. The most commonly used materials for busbars are bare aluminum, plated aluminum or plated copper. Aluminum used for busbars is EC (electrical) grade.

13–7. PREPARATION OF BUSBARS. Busbars for an aircraft electrical system must be clean and free from grease, dirt and oxide. Any of these at the electrical junction will cause the connection to heat up and fail. Busbars are cleaned prior to installation in the aircraft, and are also treated to prevent or minimize oxidation after installation.

13–8. PREPARATION OF UNPLATED ALUMINUM ALLOY BUSBARS. Clean unplated aluminum busbars by immersing in Stoddard's solvent, or by wiping with a clean, soft cloth saturated with the solvent. Wipe dry with a clean, soft cloth.

13–9. After cleaning, treat all electrical contact surfaces as follows:

a. Cover contact surfaces completely with an even coating of petrolatum-zinc dust compound (50% petrolatum, 50% fine zinc dust, by weight.)

b. Scrtach brush the coated areas, using a rotary steel wire brush with a pilot as shown in figure 13–1. Brush through the compound.

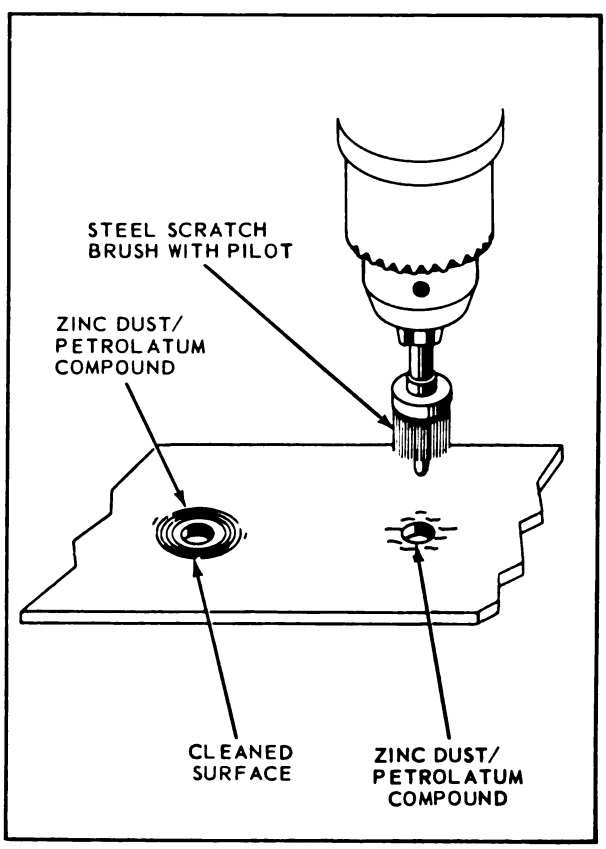


Figure 13–1. Scratch Brushing Unploted Aluminum Alloy Busbars

c. Remove most of the compound from busbar by wiping lightly with a clean soft cloth.

d. Examine busbar to make sure that there are no steel brush bristles lodged in the aluminum.

e. Apply a thin coating of clean petrolatum-zinc compound to contact surfaces. This compound is the same as that supplied in MS aluminum terminal lugs.

Note

Allow final coat of compound to remain on busbar when installed. Excess will be squeezed out of connections and removed later.

13–10. PREPARATION OF PLATED ALUMINUM AND COPPER BUSBARS. Clean plated aluminum and copper busbars thoroughly by immersing in Stoddard's solvent, or by wiping with a clean, soft cloth saturated with the solvent. Wipe dry with a clean soft cloth.

13–11. REPAIRING DAMAGED PLATING. Examine contact surfaces of plated aluminum or copper busbars for damage to plating. Reject damaged aluminum busbars and return for rework. Repair slight damage to plated copper busbars by tinning with a soldering iron, or by brush plating. Thoroughly wash and dry brush plated areas.

CAUTION

Do not attempt to repair plating on aluminum.

13–12. MOUNTING HARDWARE. See figure 13–2. When installing a copper busbar, always place a cadmium plated steel plain washer between the busbar and the lockwasher or self-locking nut. When installing an aluminum alloy busbar, place an aluminum alloy plain washer between the busbar and the lockwasher or self-locking nut.

13–13. INSULATION. Insulate the busbar from structure, junction box, or support with a fiberglass, phenolic or other rigid insulating stand-off as shown in figure 13–2. Do not use any moisture-absorbing material.

13–14. PROTECTION. Install busbars inside panels, junction boxes or in protected areas when possible. If this cannot be done, protect the busbar with vinyl tubing tied in place after connections have been made. See section XIV, paragraph 14–51, for details.

13–15. INSTALLATION OF CONDUIT.

13–16. GENERAL. Metallic conduit, both rigid and flexible, used in aircraft to protect electrical wires and cables, is installed before the wiring is routed through it. Non-metallic conduit is installed at the same time the wiring is routed, and the procedure is described in section XIV. For the preparation of conduit prior to installation see section XI.

13–17. SUPPORTING HARDWARE. Attach conduit to aircraft structure with clamps. For rigid or flexible bare metallic conduit, select a plain aluminum clamp (AN742) of the proper size from table 13–1. For rubber covered flexible metallic conduit, selecte a cushioned clamp (MS21919) of the proper size from table 13–2. Measure the OD of conduit to determine selection of size from table 13–2.

13–18. INSTALLATION OF SUPPORTING HARDWARE. Attach clamps to a rigid surface of structure, so that there will be no relative motion between conduit and aircraft structure. Install clamps so that the mounting screw is above the conduit as shown in figure 13–3. Install clamps so that conduit slants down-

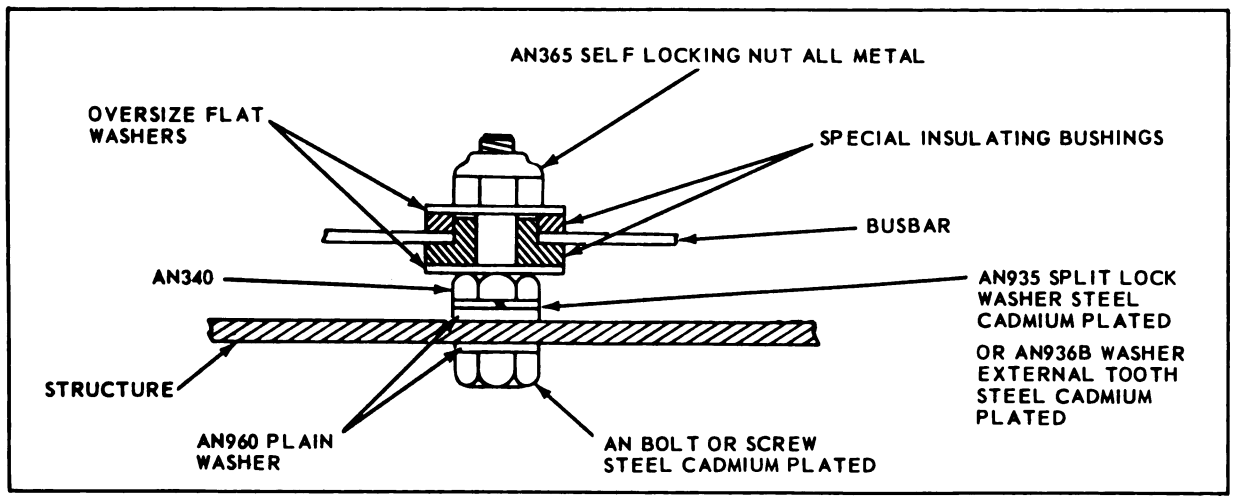


Figure 13–2. Mounting Busbars to Structure

ward toward one end, when the aircraft is on the ground, If one end is attached to equipment, slant conduit toward the open end away drom the equipment.

CAUTION

Do not tighten clamps on conduit so that they damage or collapse the conduit. Reject and replace conduit that has been collapsed.

TABLE 13–1

Support Clamps for Rigid or Flexible Bare Aluminum Conduit

Nominal OD of Conduit	AN Clamp
3/16	AN742D3
1/4	AN742D4
3/8	AN742D6
1/2	AN742D8
5/8	AN742D10
3/4	AN742D12
1	AN742D16
1–1/4	AN742D20
1–1/2	AN742D24
1–3/4	AN742D28
2	AN742D32
2–1/2	AN742D40

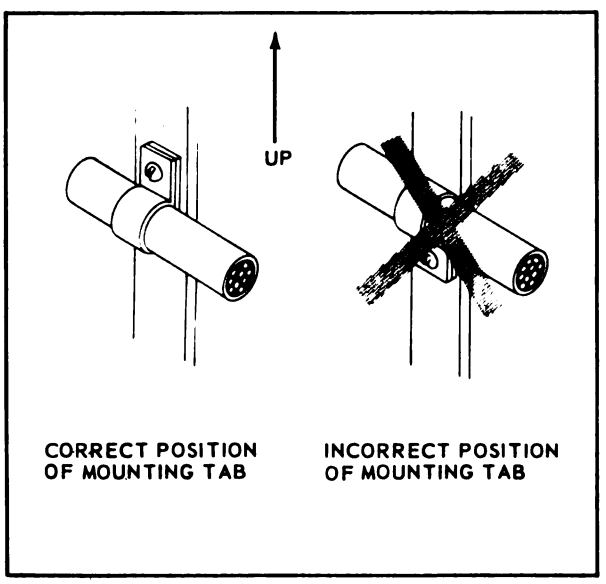


Figure 13–3. Installation of Supporting Clamps for Conduit

13–9. SPACING OF SUPPORTS. See figure 13–4. Support rigid metallic conduit with a clamp close to each end, and at maximum spacing of 3 feet along entire conduit run. Support flexible metallic conduit with clamps close to each end, and spaced 6" minimum to 24" maximum apart. Spacing of support clamps within the limits given is determined by conditions of structure.

13–20. BENDING LIMITATIONS. Rigid metallic conduit is bent as required before installation. See section XI, paragraph 11–9,, step be for procedure. Form bends in flexible metallic conduit to radii given in table 13–3. Where non-military specification conduit has been used in the aircraft, replace with conduit of same type, and bend as in the original installation.

CAUTION

Make sure that conduit is not overstressed in installation, and that there is no strain on ferrules. Install conduit so that there will be no vibration flexing of the conduit at ferrules.

13–21. DRAINAGE. Do not drill drainage holes in metallic conduit. Drainage is provided for as described in 13–18. Procedure for making drainage holes in nonmetallic conduit is described in section XIV, paragraph 14–25.

TABLE 13–2

Support Clamps for Rubber Covered Flexible Aluminum or Brass Conduit

MS Clamp Number	Nominal ID of Clamp (inches)
MS 21919D5	.313
MS 21919D6	.375
MS 21919D7	.438
MS 21919D8	.500
MS 21919D9	.563
MS 21919D10	.625
MS 21919D11	.688
MS 21919D12	.750
MS 21919D13	.813
MS 21919D14	.875
MS 21919D15	.938
MS 21919D16	1.000
MS 21919D19	1.888
MS 21919D21	1.313
MS 21919D23	1.438
MS 21919D25	1.563
MS 21919D27	1.688
MS 21919D29	1.812
MS 21919D31	1.938
MS 21919D33	2.062
MS 21919D35	2.188
MS 21919D37	2.312
MS 21919D43	2.688
MS 21919D45	2.812

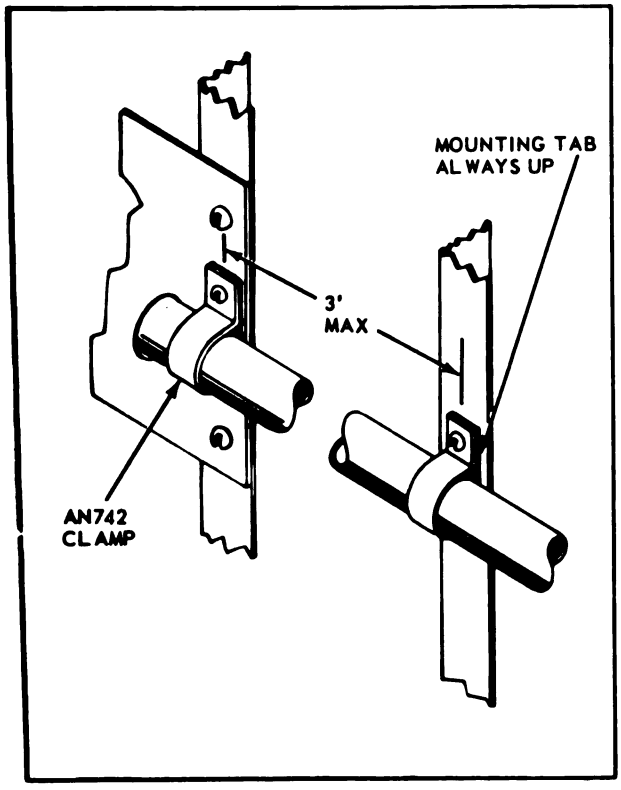


Figure 13–4. Spacing Clamps for Rigid Metallic Conduit

TABLE 13–3

Minimum Bending Radii for Flexible Aluminum or Brass Conduit

Nominal ID of Conduit (inches)	Minimum Bending Radius Inside (inches)
3/16	2–1/4
1/4	2–3/4
3/8	3–3/4
1/2	3–3/4
5/8	3–3/4
3/4	4–1/4
1	5–3/4
1–1/4	8
1–1/2	8–1/4
1–3/4	9
2	9–3/4
2–1/2	10

13–22. BONDING OR GROUNDING CONDUIT. Bond or ground metallic conduit to structure at each terminating or breaking point, by means of a plain metal clamp, or clamp and jumper. Test bond or ground as described in section VIII, paragraph 8–28.

13–23. INSTALLATION OF JUNCTION BOXES.

13–24. GENERAL. Junction boxes are containers, with hinged or removable covers, used in aircraft to provide a protected area for electrical power distribution equipment such as busbars and terminal boards. The material of junction boxes is either metal or hard fiberglass.

13–25. MOUNTING HARDWARE. See figure 13–5. Use standard AN bolts or screws of the appropriate size to attach junction boxes to aircraft structure. Insert screws or bolts so that the head of the screw or bolt is inside the junction box.

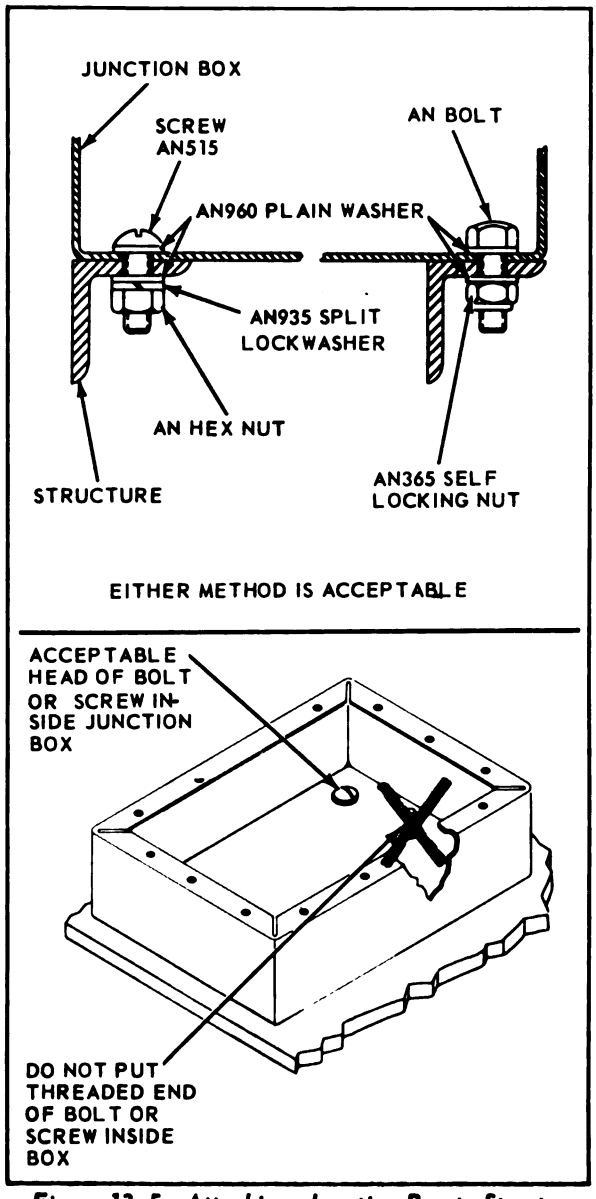


Figure 13–5. Attaching Junction Box to Structure

CAUTION

Do not install attaching hardware so that threaded part of the screw or bolt protrudes inside the junction box, as the sharp thread edges will damage wire insulation.

13–26. INSULATION. The inside of metallic junction boxes is coated with white glyptal or similar material to insulate wiring from the metal, to improve visibility and to make inspection easier. Non-metallic junction boxes need not be so insulated. If this coating is damaged during the installation procedure, repair the damaged parts with the same material as used in the original installation. When a new metallic box is installed, make sure the insulating coating is present and undamaged.

13–27. JUNCTION BOX COVERS. Junction box covers may be hinged, or attached by means of screws. Screw threads must not extend into the box. The sharp threads may cut wire insulation. If covers are not hinged, secure the cover to the box with an insulated bead chain, or No. 14 wire, as shown in figure 13–6. Make this attachment outside the box so that when the box is closed the chain or wire will not interfere with the wiring.

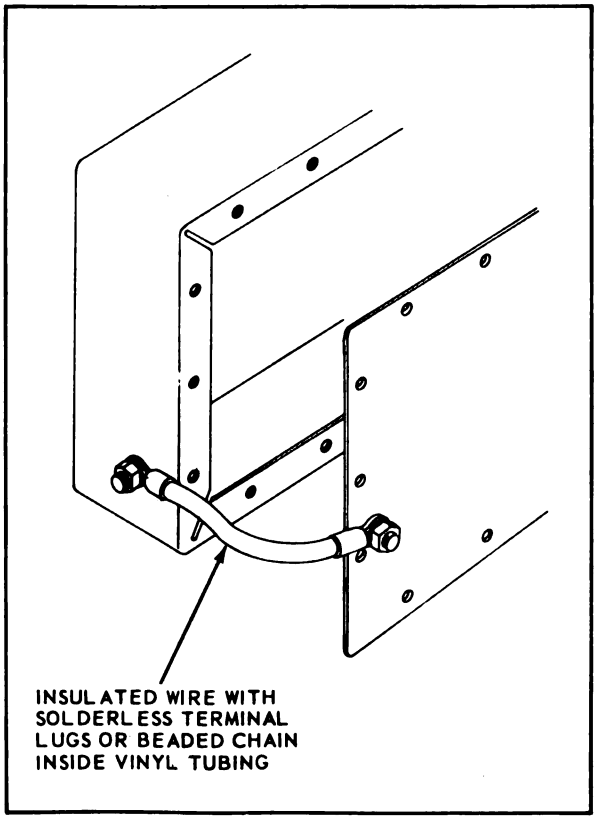


Figure 13–6. Attaching Cover to Junction Box

Note

If covers are bent during installation or repair, straighten them before final attachment.

13–28. PREPARATION OF WIRE ENTRY HOLES. Determine the outside diameter of the wire, or wire bundle, and make sure that the opening is at least 1/8 inch larger in diameter to allow for later enlargement of the bundle. Use a box connector and cable clamp to protect wiring if this is indicated on the engineering drawing. When a box connector is not used, protect the edges of the entry hole with plastic or fiber grommets. See figure 13–7.

13–29. DRAINAGE OF JUNCTION BOXES. Provide one or more drainage holes 3/16" diameter minimum, at the lowest point of the junction box when the aircraft is on the ground. After drilling drainage holes in metal junction boxes, deburr the edges of the hole with a deburring tool or a file.

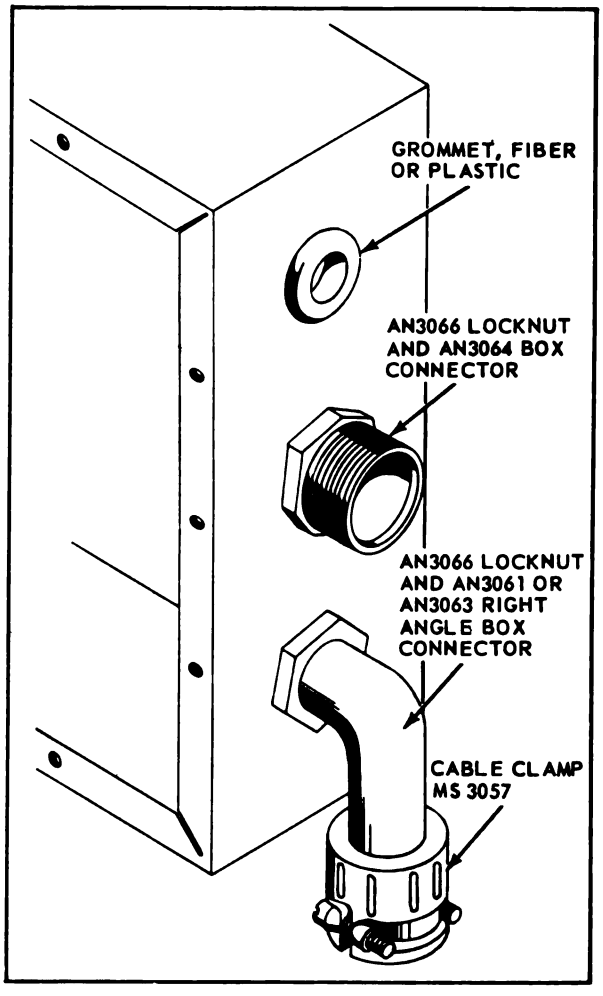


Figure 13–7. Wire Entry Holes in Junction Box

CAUTION

Do not drill holes in vapor-tight junction boxes.

13–30. VAPOR TIGHT BOXES. Vapor-tight junction boxes in aircraft are identified as such on the covers. When doing work of any kind on vapor-tight boxes carefully follow the instructions given in the aircraft manufacturers handbook of maintenance instructions for the specific airplane model.

13–31. IDENTIFICATION. If junction boxes as originally installed are not identified, it is not necessary to do so. If the junction box does have identification marking, make sure marking is replaced as in original.

13–32. BONDING OR GROUNDING JUNCTION BOXES. Bond or ground junction boxes to structure by direct metal-to-metal contact or by means of a bonding jumper. Test bond or ground as described in section VIII, paragraph 8–28.

13–33. INSTALLATION OF PROTECTIVE DEVICES.

13–34. GENERAL. Protective devices are items of electrical equipment such as circuit breakers, fuses, etc., installed in aircraft to protect the electrical system against overloads caused by short circuits or other faults. See Section XVIII for description of fuses and current limiters used in aircraft electrical systems.

13–35. MOUNTING HARDWARE. If attaching hardware is furnished with the protective device, use it. If no attaching hardware is furnished, mount the protective device with standard AN cadmium plated steel screws or bolts, of the appropriate size. When replacing a protective device, use hardware exactly the same as in the original installation except that a longer screw may be used if necessary.

CAUTION

Do not use self-tapping screws to mount protective devices.

13–36. MOUNTING WITH THROUGH BOLTS OR SCREWS. When possible attach protective devices to aircraft structure or other support with through bolts or screws. Install a plain washer under the head of the bolt or screw, and a plain washer and a split lock-washer under the nut. See figure 13–8.

13–37. MOUNTING INTO TAPPED HOLE OR NUT PLATE. When it is necessary to install a protective device with a screw into a tapped hole or a nut plate, install a plain washer and a split lock-washer under the screw or bolt head. See figure 13–9.

13–38. MOUNTING INTO BLIND HOLE. When a protective device must be attached with a screw into a blind tapped hole, make sure that the screw will give maximum thread engagement without bottoming in the hole. The length is determined as follows: See figure 13–10.

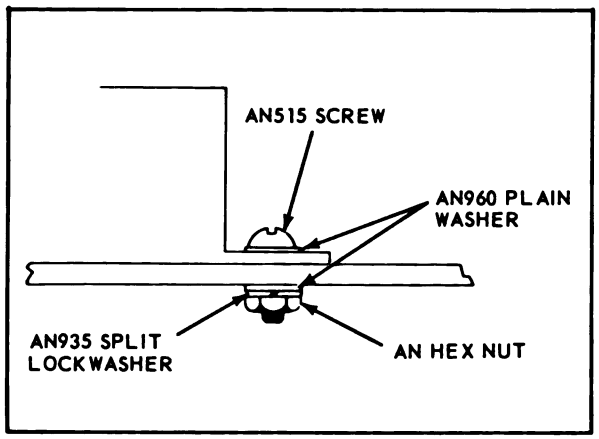


Figure 13–8. Mounting Protective Devices

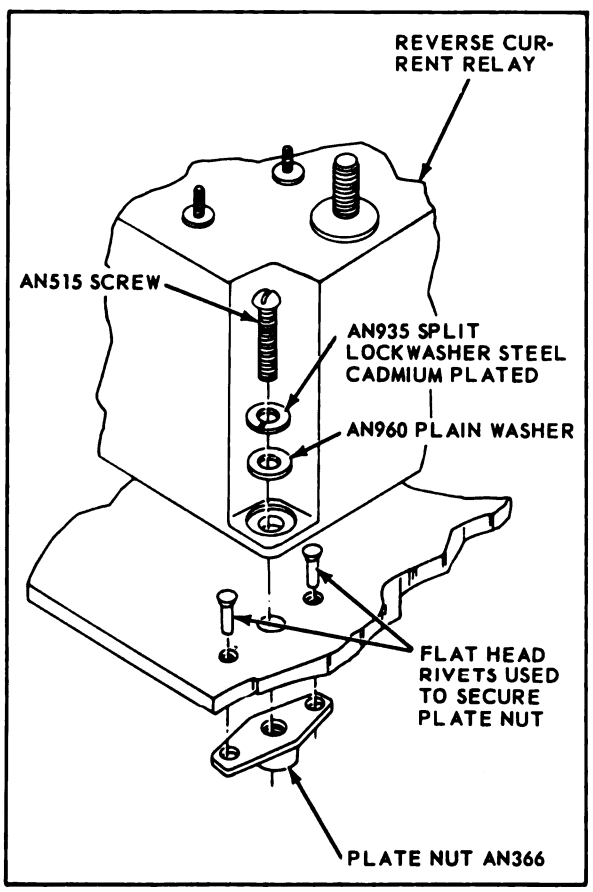


Figure 13–9. Typical Mounting Hardware for Protective Devices

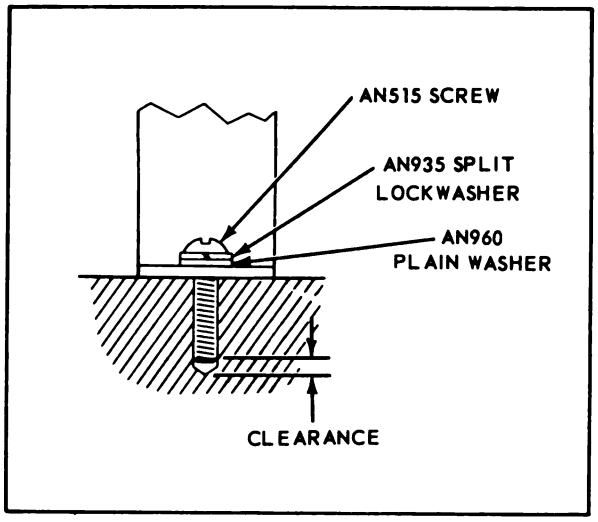


Figure 13–10. Determining Screw Length for Mounting into Blind Holes

a. Select a screw of approximately the correct length and install a plain washer and lock washer on it.

Note

Do not mount the protective device when determining screw length.

b. Insert the screw into the blind tapped hole, and thread it in until it bottoms in the hole. Plain and lock in washers should remain free.

c. Back out the screw two turns, and measure the length of screw between the under surface of the head and the top washer.

d. Measure the thickness of the mounting part of the protective device, and subtract it from the measurement obtained in step c. If the device to be mounted is thicker than the dimension obtained in step c, repeat steps a, b, and c, using a longer screw.

e. Subtract dimension obtained in step d, from the overall length of the screw; this will give the maximum length which can be used without bottoming in the tapped hole. If the final length is not a standard length, use the next shorter standard screw.

13–39. MOUNTING CIRCUIT BREAKERS. Mount switch circuit breakers so that when the switch breaker is in the off, or open position, the handle will be down or to the rear.

13–40. MOUNTING RELAYS. Mount relays so that foreign particles cannot fall between the terminals, and so that liquid cannot accumulate inside the cover.

13–41. SPECIAL PRECAUTIONS FOR BONDING OR GROUNDING CONNECTIONS. When a bond or ground connection is made through the mating surfaces of structure and mounting pad, prepare the contacting surfaces as described in section VIII, paragraph 8–13, before attaching the device to structure.

13–42. PROTECTION. If possible mount protective devices in junction boxes or protected areas. If this is not possible, and the devices are to be installed in locations where they may be subject to damage or where the terminals may be dangerous to personnel, provide a cover to go over the protective device.

13–43. PROTECTIVE COATING FOR ELECTRICAL CONNECTIONS. Electrical connections to protective devices may be protected against moisture, corrosion and damage from metal particles by the application of a strippable polyurethane coating. A typical commercial compound of this type is PR 1532, made by the Products Research Corporation. The procedure for application is as follows:

a. Clean surfaces to be coated with a clean soft bristle brush.

b. Thoroughly mix the two parts of the compound together, in the proportions recommended by the manufacturer.

c. Using the injection nozzle of a pressure gun, apply a 1/16 inch minimum thick coating over the connection, and extending 1/8 inch beyond the connection all around.

d. Cure as recommended by the manufacturer. Protect the coated parts during the cure by covering with polyethylene sheeting.

13–44. IDENTIFICATION. Make sure that each protective device is identified by a plate or decal, permanently attached to adjacent aircraft structure. If the location of a protective device is changed make sure that the identification marking is also relocated, and completely visible. Make sure the new identification marking is exactly the same as the original.

13–45. INSTALLATION OF TERMINAL BOARDS.

13–46. GENERAL. Terminal boards are used in aircraft to provide junction points of good electrical conductivity for circuits which are not frequently disconnected.

13–47. MOUNTING HARDWARE. Use standard AN cadmium plated steel hardware of the appropriate size.

13–48. METHOD OF ATTACHMENT. Install mounting screws to that the screw protrudes through the bottom of the terminal board, as shown in figure 13–11. The length of the screw should allow for some protrusion beyond the nut. Pass a steel scale or other flat piece of metal over the top of the nut. If it passes over freely, the screw is too short, and is to be replaced with the next longer length. Protrusion of screw should not exceed two threads.

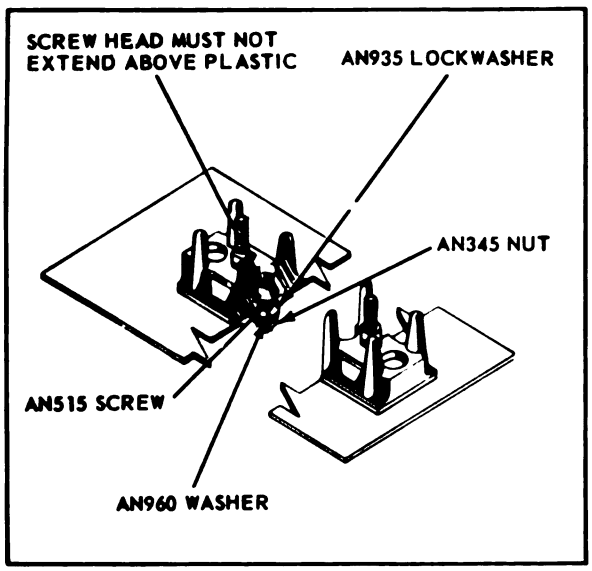


Figure 13–11. Mounting of Terminal Board

13–49. ALTERNATE METHOD OF ATTACHMENT. If it is not possible to install the mounting screw from the top of the terminal board, install it from the back as shown in figure 13–12. In this case, the end of the screw should project just beyond the top of the nut, but do not use a screw that will extend beyond the level of the terminal board mounting surface.

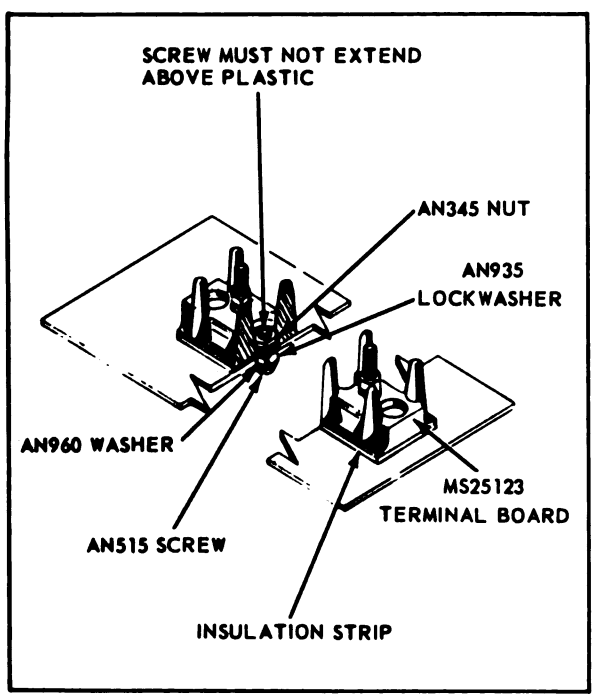


Figure 13–12. Alternate Mounting of Terminal Board

13–50. INSULATION. See figure 13–13. Place an insulating strip over each mounting screw, long enough so it will go over the two adjacent terminal studs under the washers and nut which secure each stud.

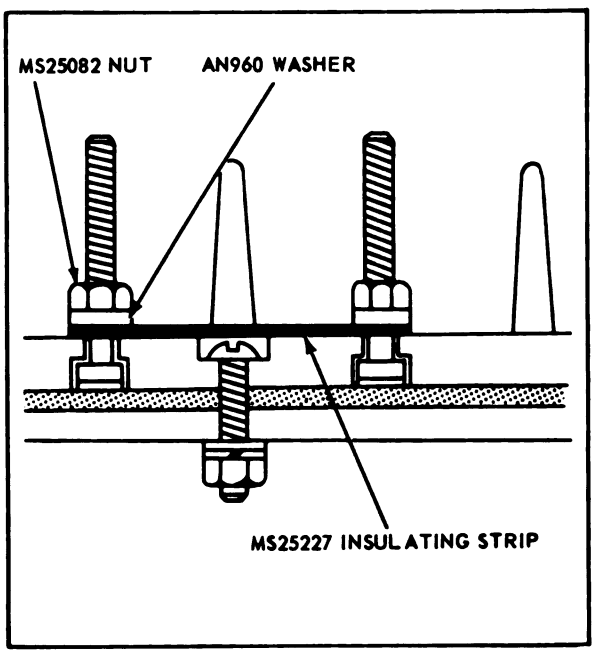


Figure 13–13. Insulation of Terminal Board

13–51. ATTACHING BUSBAR TO TERMINAL BOARD. When a busbar is to be attached to a terminal board mount the busbar directly on top of the nut which holds the terminal stud in place. Terminal lugs are then installed on top of the busbar as described in Section XIV, paragraphs 14–43 through 14–49.

Note

If aluminum busbars are removed, and are to be replaced, examine the busbar for deformation before replacing it. If there is any deformation, discard it, and install a new busbar.

13–52. PROTECTION OF TERMINAL BOARDS. Where possible, mount terminal boards inside junction boxes or other enclosures. If this is not possible, and the terminal board is located where it may be damaged, or may be dangerous to personnel, provide a cover. Use terminal board cover MS17777 on the MS25123 terminal board. Use terminal board cover MS18029 on the MS27212 terminal board. Attach no more than two terminal lugs on the stud which is to be used for mounting the cover to the terminal board. If no cover is available, the terminal board may be protected by a wrapping of vinyl sheeting. Use a piece of vinyl sheet large enough to make a generous lap over the studs. Punch holes in the vinyl sheet, install it over grounded studs, and fasten with nuts and washers.

13–53. IDENTIFICATION. Each terminal board in the aircraft electrical system is identified by the letters TB followed by a number which is the number of the individual board. Each stud on the terminal board is identified by a number adjacent to it, with the lowest number in the series at the end nearest the terminal board identification number. (See figure 13–14). The identification may be marked on the aircraft structure to which the terminal board is attached, or may be on an identification strip cemented to the structure, under the terminal board. When a terminal board is replaced, do not remove the identification marking unless it has been damaged. In that case, replace the identification marking exactly as in the original, in accordance with the applicable wiring diagram.

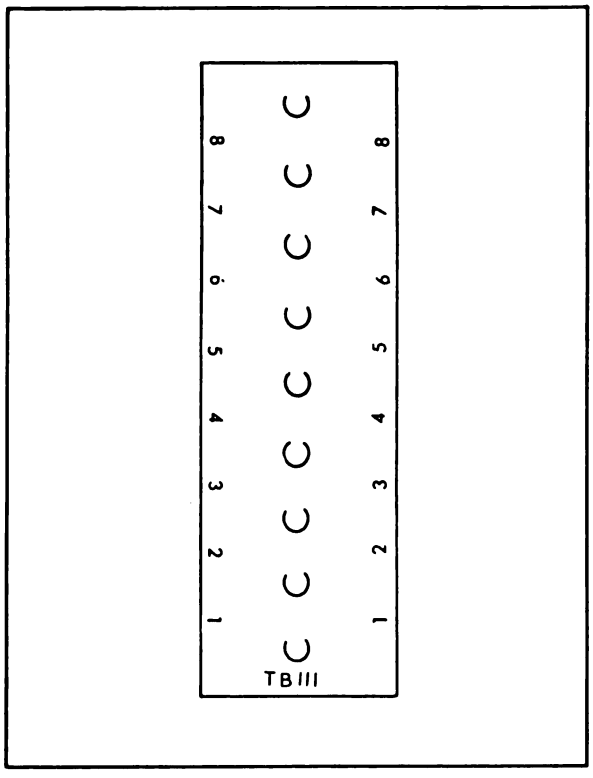


Figure 13–14. Identification of Terminal Board

SECTION XIV

ELECTRICAL WIRING INSTALLATION

14–1. INTRODUCTION.

14–2. SCOPE. This section describes recommended procedures for installing electrical wiring and related accessories in military aircraft.

14–3. REFERENCE SPECIFICATIONS AND DRAWINGS.

MIL-W-5088	Wiring Aircraft, Installation of
MIL-S-8516	Sealing Compound, Synthetic Rubber Electric Connectors and Electric Systems, Accelerator Required
MIL-C-21565	Clamp, Loop, Plastic, Wire Support
MS21265	Grommet, Plastic, Split
MS21919	Clamp, Cushioned, Support, Loop Type, Aircraft
MS25281	Clamp, Loop, Plastic, Wire Support
MS35489	Grommet, Rubber, Hot Oil and Coolant Resisting
MS35490	Grommet, Rubber, Split, General Purpose
AN735	Clamp, Loop Type, Bonding

14–4. DEFINITIONS.

a. Open Wiring. Any wire, wire group or wire bundle not enclosed in conduit.

b. Wire Group. Two or more wires going to the same location, tied together to retain identity of the group.

c. Wire Bundle. Two or more wire groups, tied together because they are going in the same direction at the point where the tie is located.

d. Wire Harness. A wire group or bundle tied together as a compact unit (open harness), or contained in an outer jacket (enclosed harness). Wire harnesses are usually pre-fabricated and installed into the aircraft as a single assembly. Two examples of enclosed wire harnesses as described in section XII.

e. Electrically Protected Wiring. Those wires which include in the circuit protection against overloading such as fuses, circuit breakers or other limiting devices.

f. Electrically Unprotected Wiring. Those wires (generally from generators to main bus distribution points) which do not have protection such as fuses, circuit breakers or other current limiting devices.

14–5. WIRE TYPES. The wires most commonly used in aircraft electrical systems are in accordance with the specifications listed in table 14–1. See section II, table 2–1 for details of conductor, insulation, voltage and temperature.

14–6. WIRE GROUPS AND BUNDLES.

14–7. WIRE SEPARATION. Military Sepcification MIL-W-5088 restricts the grouping or bundling of certain wires such as electrically unprotected power wiring, and wiring to duplicate vital equipment. Do not add such wires to existing bundles unless specifically authorized.

14–8. SIZE OF WIRE BUNDLE. Military specifications generally limit the size of a wire bundle to 75 wires, or two inches diameter, whichever is smaller.

14–9. IDENTITY OF GROUPS WITHIN BUNDLES. When several wires are grouped at junction boxes, terminal boards, panels, etc., retain the identity of the group within a bundle by spot ties, as shown in figure 14–1.

14–10. COMBING WIRES. Comb out all wires, except those listed in 14–11, so that wires will be parallel to each other in group or bundle. A useful tool for combing out wires is shown in figure 14–2. Make this tool from a piece of 1/8 inch nylon or other smooth insulating material. Be sure all sharp edges are rounded to protect wire insulation.

14–11. TWISTING WIRES. When specified on applicable engineering, drawings, twist together the following wires:

a. Wiring in vicinity of magnetic compass or flux valve.

b. Three-phase distribution wiring.

c. Other wires (usually sensitive circuit avionic wiring) as specified on engineering drawings.

Twist wires so they lie snugly against each other, making approximately the number of twists given in table 14–2. Check wire insulation for damage after twisting If insulation is torn or frayed, replace the wire

14–12. SPLICED CONNECTION IN BUNDLES. Locate spliced connections in wire groups or bundles so that they can be inspected. Stagger splices as shown in figure 14–3. so that the bundle does not become excessively enlarged. Make sure that all non-insulated splices are covered by shrinkable tubing or by plastic sleeves securely tied at both ends.

TABLE 14–1

Wire Types

1. 600 Volts or Under

General Purpose	Aluminum	High Temperature	Fire Resistant
MIL-W-5086 Types I, II and III	MIL-W-7072	MIL-W-7139 MIL-W-8777 MIL-W-18678, Type E *MIL-W-22759 MIL-W-27300	MIL-W-25038

2. Over 600 Volts

MIL-W-5086, Type IV
MIL-W-16878, Type EE
*MIL-W-22759

3. Cabled, Shielded and Jacketed

MIL-C-5767
MIL-C-7078
MIL-C-27500

*MIL-W-22759 covers wire rated at 600 volts-and 1000 volts.

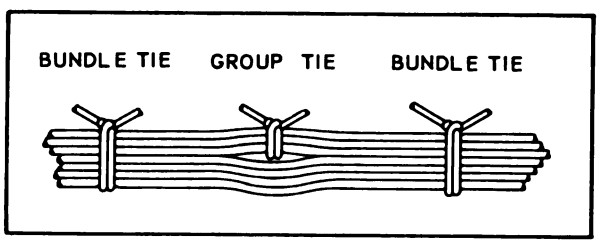


Figure 14–1. Group and Bundle Ties

14–13. SLACK. Do not install single wires or wire bundles with excessive slack. Slack between support points such as cable clamps should normally not exceed 1/2 inch. (See figure 14–4). This is the maximum that it should be possible to deflect the wire with moderate hand force. This may be exceeded if the wire bundle is thin and the clamps are far apart but the slack must never be so great that the wire bundle can touch any surface against which it may abrade. Allow a sufficient amount of slack near each end for any or all of the following:

a. To permit ease of maintenance.

b. To allow replacement of terminals at least twice.

c. To prevent mechanical strain on the wires, cables, junctions and supports.

d. To permit free movement of shock-and-vibration mounted equipment.

e. To permit shifting of equipment for purposes of maintenance, while installed in the aircraft.

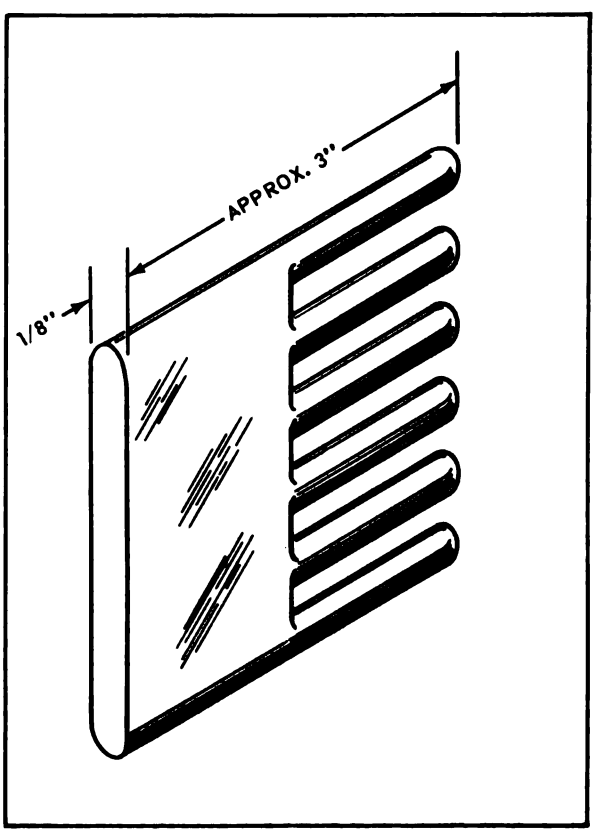


Figure 14–2. Comb for Straightening Wires in Bundles

TABLE 14–2

Twists Per Foot

Wire Size	#22	#20	#18	#16	#14	#12	#10	#8	#6	#4
2 Wires	10	10	9	8	7–1/2	7	6–1/2	6	5	4
3 Wires	10	10	8–1/2	7	6–1/2	6	5–1/2	5	4	3

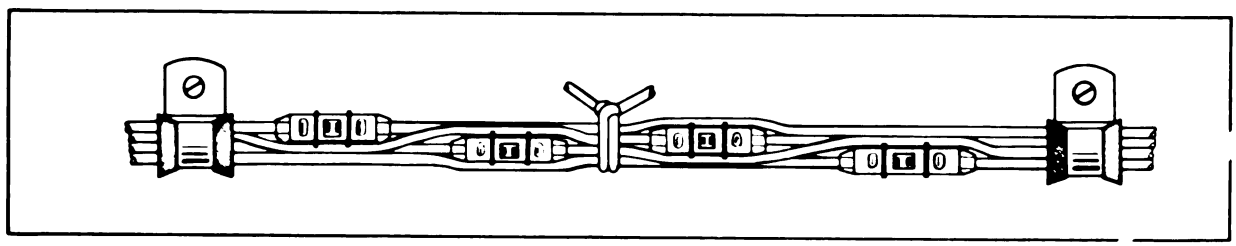


Figure 14–3. Staggered Splices in Wire Bundle

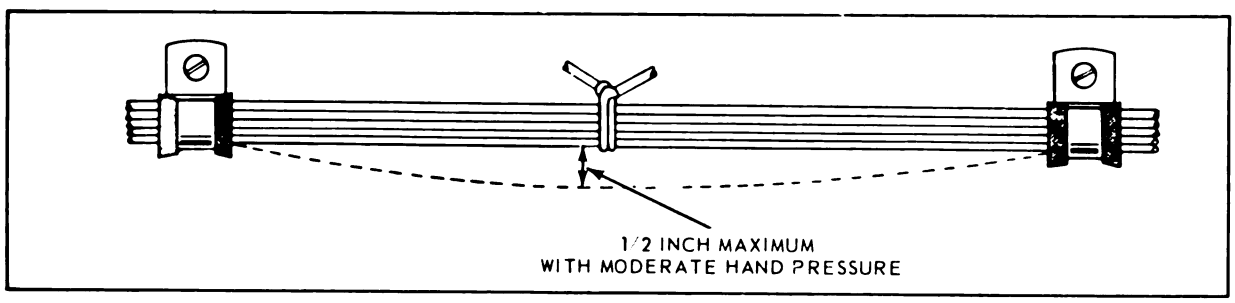


Figure 14–4. Slack Between Supports

14–14. BEND RADII. Bend individual wires to a minimum radius of ten times the outside diameter of the wire, except at terminal boards where the wire is suitably supported at each end of bend, a minimum radius of three times the outside diameter of the wire is acceptable. Bend wires in wire bundles to a minimum radius of ten times the outside diameter of the largest wire in the bundle.

CAUTION

Never bend coaxial cable to a smaller radius than six times the outside diameter.

When it is not possible to hold the bending radius of single wires to the above limits, enclose wire in tight plastic tubing for at least two inches each side of the bend.

14–15. ROUTING AND INSTALLATION.

14–16. GENERAL INSTRUCTIONS. Install wiring so that it is mechanically and electrically sound, and neat in appearance. Wherever practicable, route wires and bundles parallel with, or at right angles to the stringers or ribs of the area involved, as shown in figure 14–5.

Note

Route coaxial cable as directly as possible. Avoid unnecessary bends in coaxial cable. Locate attachments at each frame rib on runs along the length of the fuselage, or at each stiffener on runs through the wings.

14–17. GENERAL PRECAUTIONS. When installing electrical wiring in aircraft, observe the following precautions:

a. Do not permit wire or wire bundles to have moving, frictional contact with any other object.

b. Do not permit wire or wire bundles to contact sharp edges of structure, holes, etc. (Refer to 14–20).

c. Do not use any installing tools other than those specifically authorized.

d. Do not damage threads of attaching hardware by overtightening or cross-threading.

e. Do not subject wire bundles to sharp bends during installation. (Refer to 14–14).

f. Do not allow dirt, chips, loose hardware, lacing tape scraps, etc. to accumulate in enclosures or wire bundles.

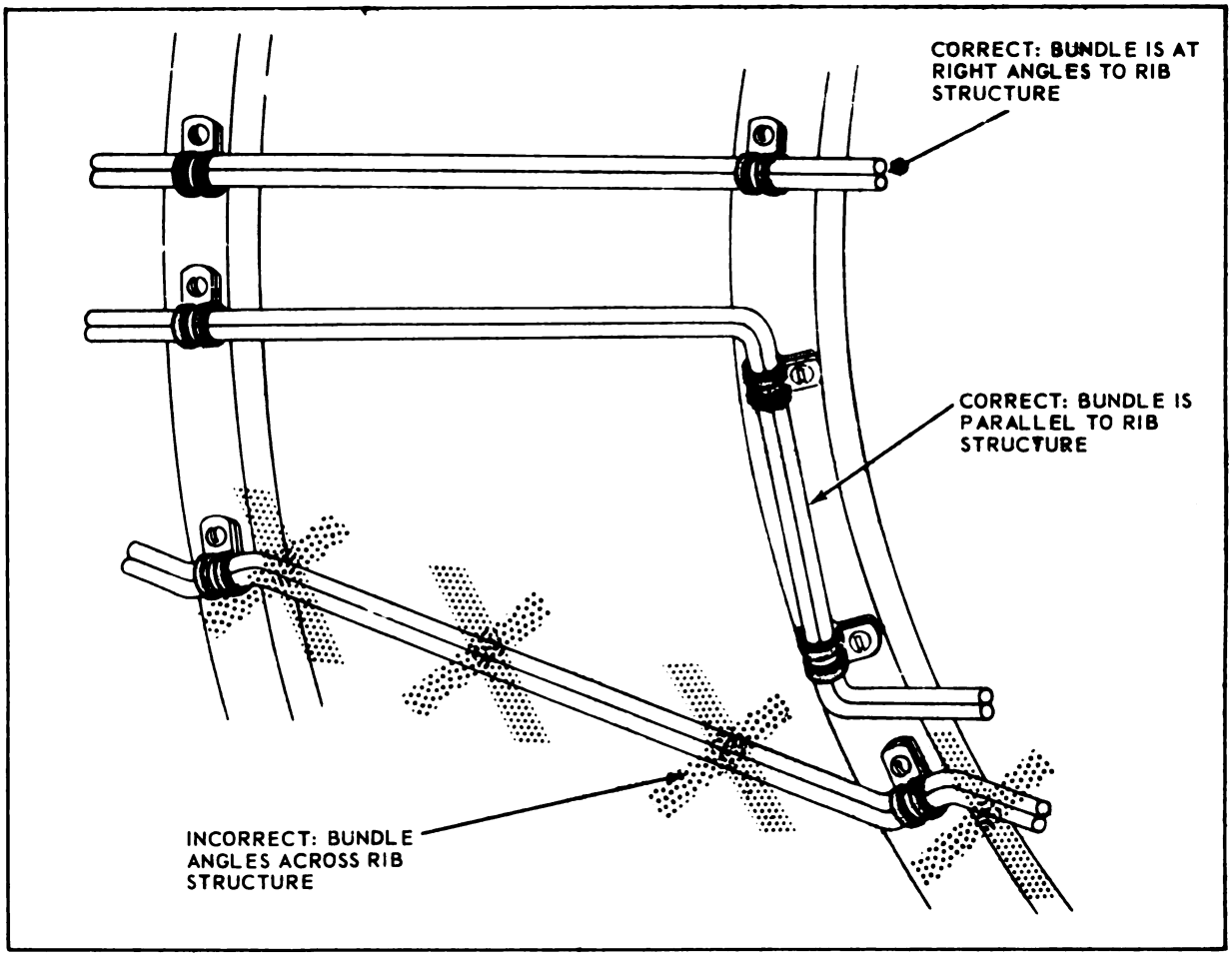


Figure 14–5. Routing Bundles

g. Do not hang tools or personal belongings on wire bundles.

h. Do not use installed wire bundles or equipment as footrests, steps, or handholds.

i. Do not compensate for wires that are too long by folding wire back on itself and hiding such folds within bundles.

j. Do not twist or pull wire bundles during assembly or installation so pins are pulled from connectors, or connectors or wires otherwise damaged.

k. Do not stretch wires to mate connectors; allow sufficient slack to permit easy mating.

14–18. SUPPORT. Bind and support wire and wire bundles to meet the following requirements:

a. Prevent chafing of cables.

b. Secure wires and wire bundles routed through bulkheads and structural members.

c. Fasten wires in junction boxes, panels and bundles for proper routing and grouping.

d. Prevent mechanical strain that would tend to break the conductors and connections.

e. Prevent arcing or overheated wires from causing damage to mechanical control cables.

f. Facilitate re-assembly to equipment and terminal boards.

g. Prevent interference between wires and other equipment.

h. Permit replacement or repair of individual wires without removing the entire bundle.

i. Prevent excessive movement in areas of high vibration.

14–19. PROTECTION. Install and route wires and wire bundles to protect them from the following:

a. Chafing or abrasion.

b. High temperature.

c. Use of wire bundles as handholds, footrests or steps, or as support for personal belongings and equipment.

d. Damage by personnel moving within the aircraft.

d. Damage from cargo stowage or shifting.

f. Damage from battery acid fumes, spray or spillage.

g. Damage from solvents and fluids.

h. Abrasion in wheel wells where exposed to rocks, ice, mud, etc.

14–20. PROTECTION AGAINST CHAFING. Install wires and wire groups so they are protected against chafing or abrasion in locations where contact with sharp surfaces or other wires would damage the insulation. Damage to the insulation may result in short circuits, malfunction or inadvertent operation of equipment. Use Military Standard cable clamps to support wire bundles at each hole through a bulkhead. See figure 14–6. If wires come closer than 1/4 inch to edge of hole install a suitable grommet in hole as shown in figure 14–7.

CAUTION

Do not depend on vinyl sleeving as protection against abrasion or chafing, or as a substitute for good routing practice.

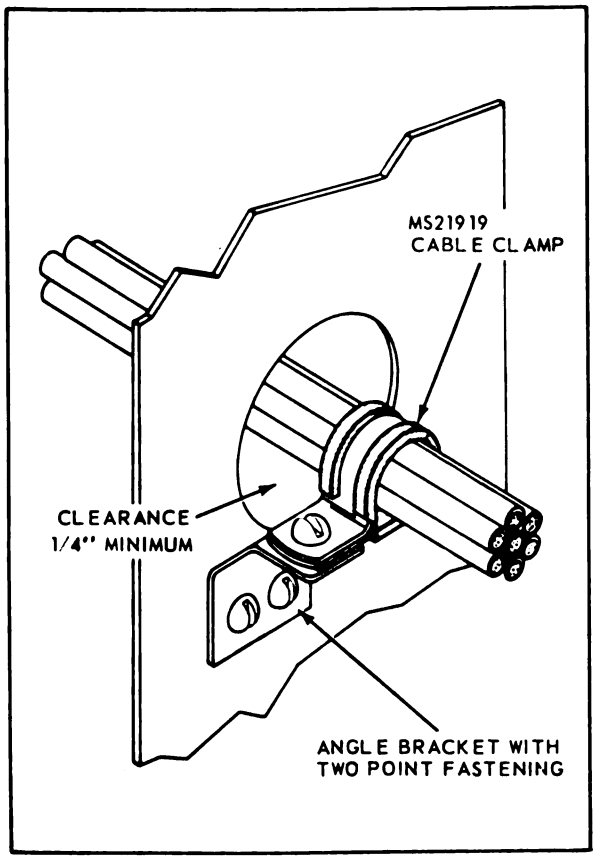


Figure 14–6. Cable Clamp at Bulkhead Hole

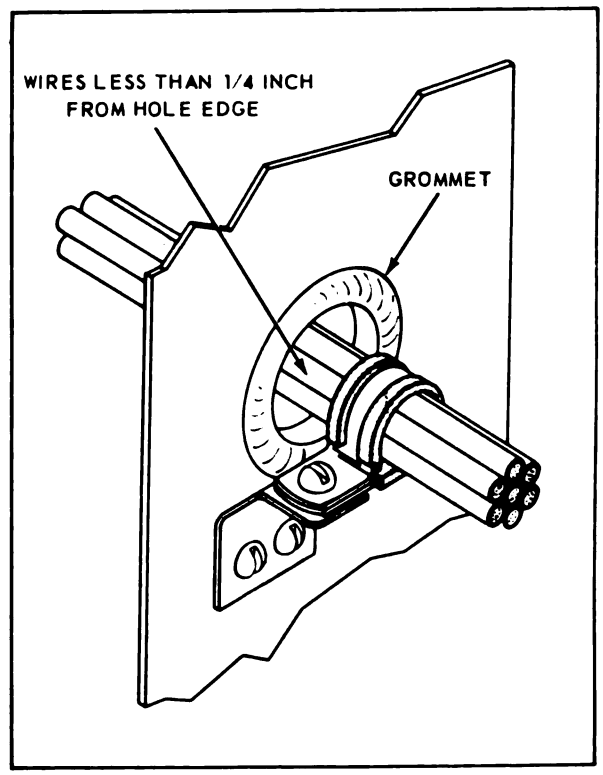


Figure 14–7. Cable Clamp and Grommet at Bulkhead Hole

14–21. PROTECTION AGAINST HIGH TEMPERATURE. To prevent wire insulation deterioration, keep wires separate from high temperature equipment such as resistors, exhaust stacks, heating ducts, etc. The amount of separation is specified by engineering drawings. If wires must be run through hot areas, insulate the wires with high temperature material such as asbestos, fiber-glass, or TFE. Additional protection in the form of conduit may be specified by engineering.

CAUTION

Never use a low temperature insulated wire to replace a high temperature insulated wire.

Many coaxial cables have soft plastic insulation such as polyethylene. These are especially subject to deformation and deterioration at elevated temperatures. Avoid all high temperature areas with these cables.

14–22. Give additional abrasion protection to asbestos wires enclosed in conduit. Use conduit with a high temperature rubber liner, or enclose asbestos wires individually in high temperature plastic tubing before installing in conduit.

14–23. PROTECTION AGAINST PERSONNEL AND CARGO. Install wire bundles so they are protected by the structure. Use structure or conduit to prevent

pinching against the air frame by cargo. Locate wire bundles so that personnel are not tempted to use sections of the wire runs as hand holds or ladder rungs.

14–24. PROTECTION AGAINST BATTERY ACIDS. Never route any wires below a battery. Inspect wires in battery areas frequently. Replace any wires which are discolored by battery fumes.

14–25. PROTECTION AGAINST SOLVENTS AND FLUIDS. Avoid areas where wires will be subjected to damage from fluids. Wires and cables installed in aircraft bilges shall be installed at least six inches from the aircraft centerline. If there is a possibility that wire without a protective outer jacket may be soaked in any location, use plastic tubing to protect it. This tubing should extend past the wet area in both directions and be tied at each end if the wire has a low point between the tubing ends. The lowest point of the tubing should have a 1/8 inch drainage hole as shown in figure 14–8. Punch the hole in the tubing after the installation is complete and the low point definitely established. Use a hole punch to cut a half circle. Be careful not to damage any wires inside the tubing when using the punch.

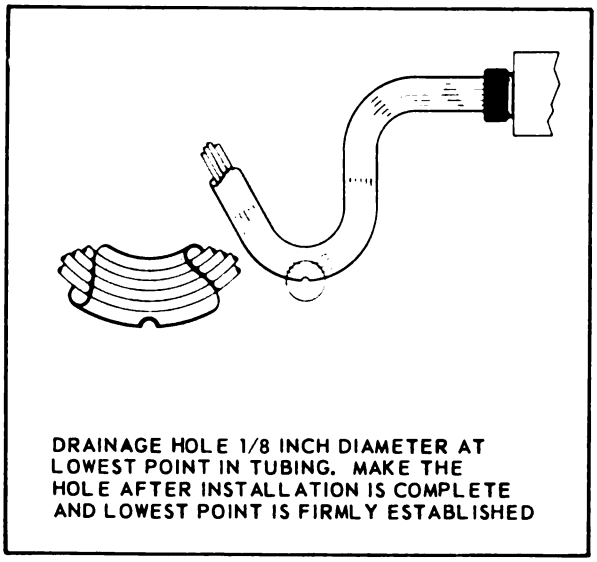


Figure 14–8. Drainage Hole in Low Point of Tubing

14–26. PROTECTION IN WHEEL WELLS AND WING FOLDS. Wires located in wheel wells and wing folds are subject to many additional hazards such as exposure to fluids, pinching, and severe flexing in service. Make sure that all wire bundles are protected by sleeves of flexible tubing securely held at each end. There should be no relative movement at point where flexible tubing is secured. Inspect these wires and the insulating tubing carefully at very frequent intervals. (See applicable Handbook of Maintenance Instructions for frequency of inspection.) Replace wires and/or tubing at the first sign of wear. There should be no strain on attachments when parts are fully extended but slack should not be excessive.

14–27. SEPARATION FROM PLUMBING LINES. When wiring must be routed parallel to combustible fluid or oxygen lines for short distances, maintain as much fixed separation as possible; six inches or more. Route the wires on a level with, or above, the plumbing lines. Space clamps so that if a wire is broken at a clamp it will not contact the line. Where a six-inch separation is not possible, clamp both the wire bundle and the plumbing line to the same structure to prevent any relative motion. If the separation is less than two inches but more than 1/2 inch use a nylon sleeve over the wire bundle to give further protection. Use two cable clamps back to back as shown in figure 14–9 to maintain a rigid separation only (not for bundle support).

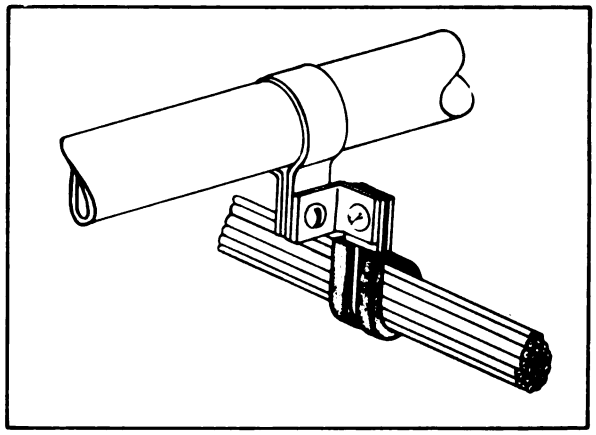


Figure 14–9. Separation of Wires from Plumbing Lines

CAUTION

Do not route any wire so that is can possibly come closer than 1/2 inch to a plumbing line.

WARNING

Never *support* any wire or wire bundle from a plumbing line carrying *flammable fluids* or *oxygen.* Clamps may be used only to insure separation.

14–28. Route wiring to maintain a minimum clearance of three inches from control cables. If this is not possible, install mechanical guards to prevent contact of wiring with control cables

14–29. INSTALLATION OF CABLE CLAMPS. Install MS21919 cable clamps as shown in figure 14–10. The mounting screw should be above the wire bundle, if possible. It is also desirable that the back of the

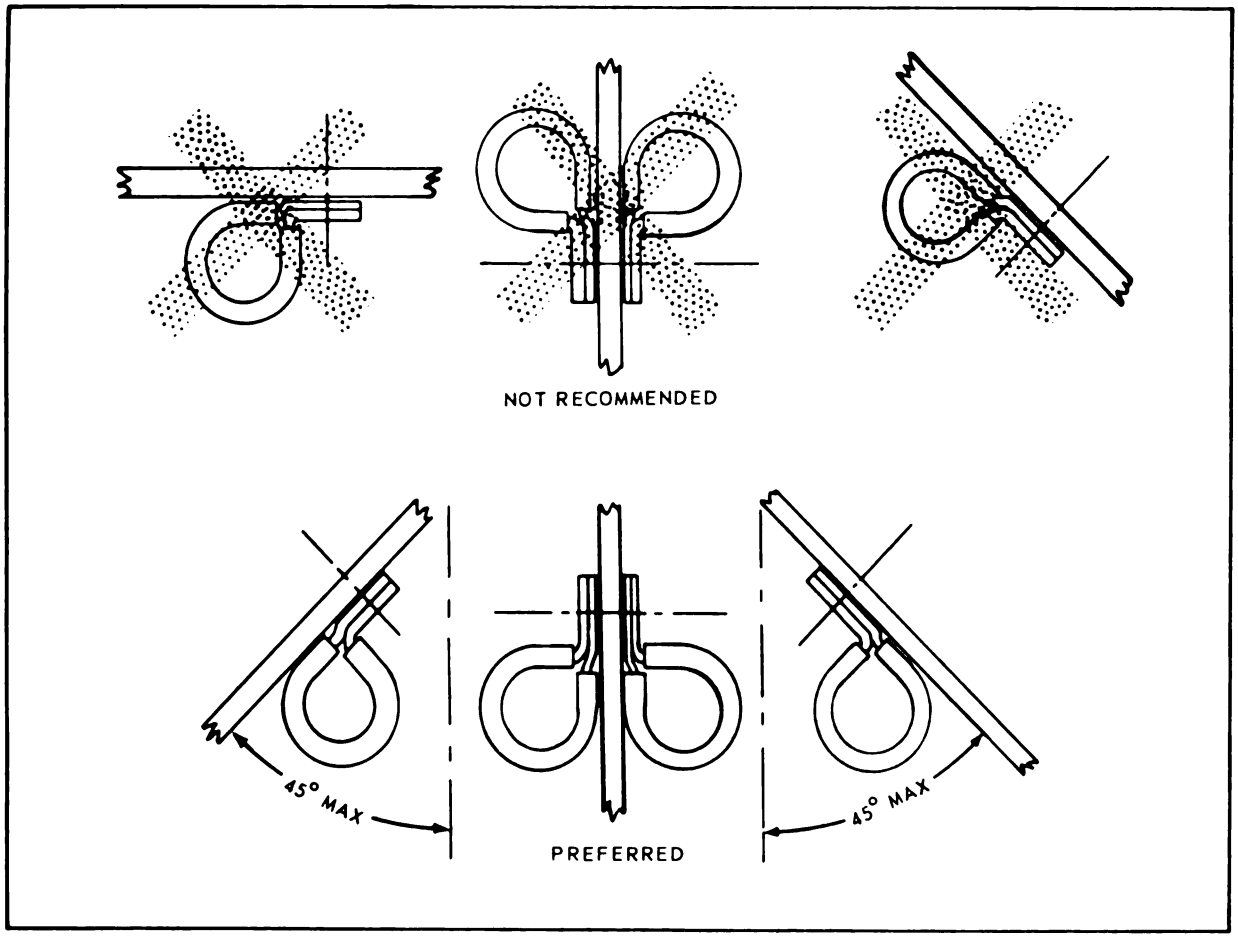


Figure 14–10. Preferred Angle for Cable Clamps

cable clamp rest against a structural member. Use hardware as shown in figure 14–11. to mount cable clamps to structure. Be careful not to pinch wires in cable clamp. If the wire bundle is smaller than the nearest clamp size, or if a clamp of the proper size is not available, wrap the wire bundle with the necessary number of turns of vinyl tape so that the bundle will be held securely in the clamp.

Note

MS21919 cable clamps are cushioned with insulating material to prevent abrasion of wires. Never use metal clamps without cushions to hold wires.

14–30. Nylon cable clamps, MS25281, may be used to support wire bundles up to two inches in diameter in open wiring, or inside junction boxes and on the back of instrument panels. When installing nylon cable clamps, use a large diameter metal washer under the screw head or nut adjacent to the clamp.

CAUTION

Do not use nylon cable clamps where the ambient temperature may exceed 235°F.

14–31. Mount cable clamps directly to "Z" members of structure. Use angle bracket with two mounting screws if structural member is angle as shown in figure 14–12.

14–32. A tool to facilitate the installation of cable clamps is shown in figure 14–13; this tool is available as item FSN G5120-703-9565. Similar to conventional multiple slip joint pliers, the tool compresses and holds the clamp with the securing bolt in place while a nut is being installed on the bolt. The tool is particularly useful for installing clamps in restricted areas, and for installing groups of two or three clamps.

14–33. INSTALLING CABLE CLAMPS TO TUBULAR STRUCTURE. Use AN735 clamps without cushions for clamping to tubular structure. The clamps must fit tightly but should not deform when locked in place. Attach wire bundle in MS21919 cable clamp to the AN735 clamp with AN hardware as shown in figure 14–14.

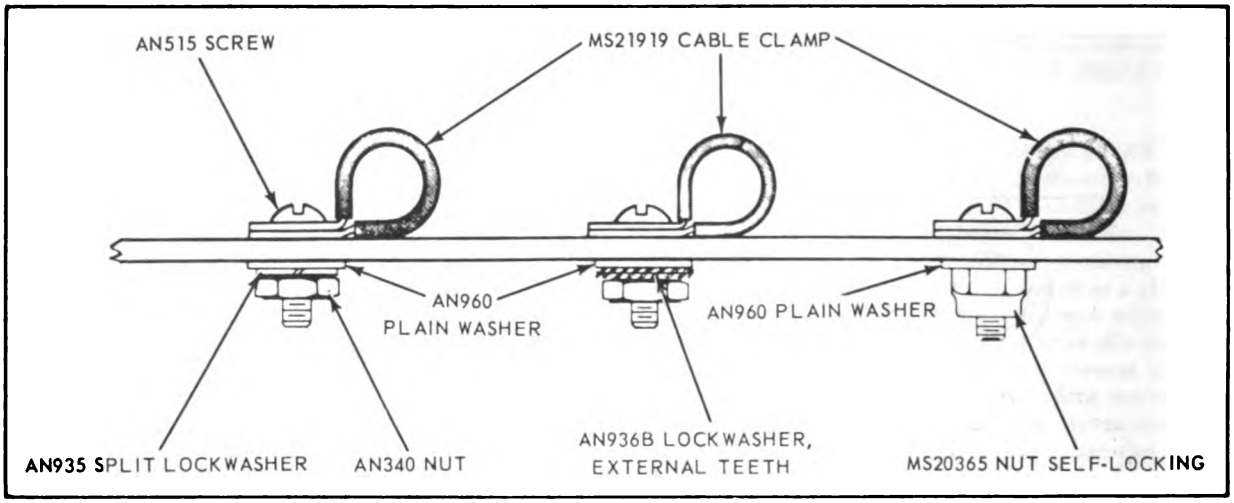


Figure 14–11. Typical Mounting Hardware for MS 21919 Cable Clamps

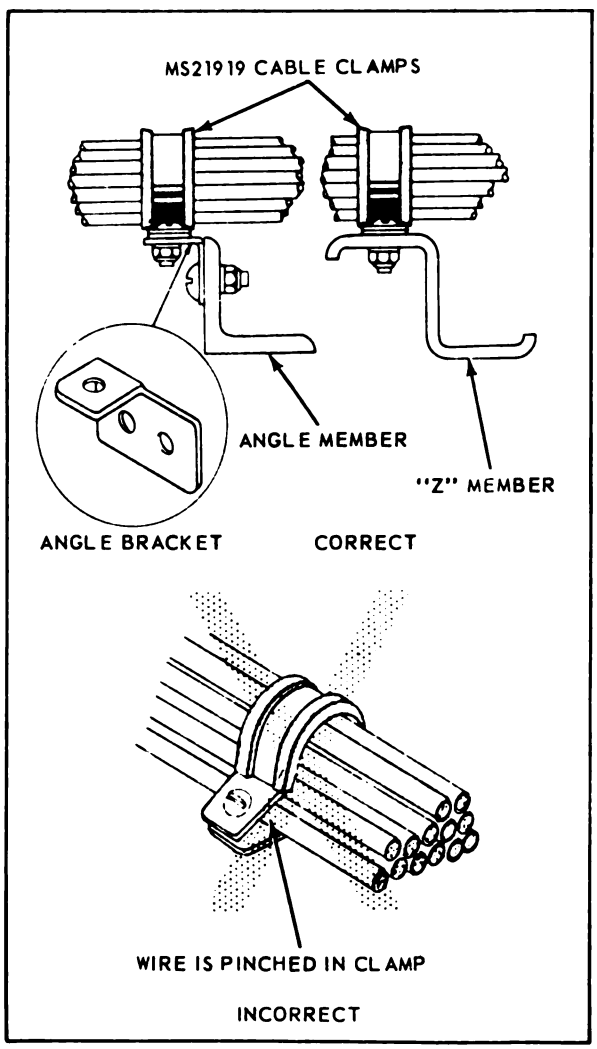


Figure 14–12. Attaching Cable Clamp to Structure

14–34. INSTALLING GROMMETS. Military Standard grommets are available in rubber, nylon and TFE. Select grommet suitable for the environmental conditions from table 14–3.

TABLE 14–3

Grommets - Temperature Limitations of Material

Standard	Material	Upper Temperature Limit
MS35489	Rubber, Hot Oil and Coolant Resistant	250°F
MS35490	Rubber, General Purpose	250°F
MS21265 and MS21266	Nylon	235°F
MS21265 and MS21266	TFE	500°F

If it is necessary to cut a nylon grommet in order to install it, make the cut at an angle of 45 degrees as shown in figure 14–15. Cement the grommet in place with general purpose cement, with the cut at the top of the hole. When installing caterpillar grommets, cut the grommet to the required length, making sure to cut square between the teeth as shown in figure 14–16. Cement the grommet in place with general purpose cement, with the cut at the top of the hole.

14–35. CONNECTIONS TO TERMINAL BOARDS AND BUSBARS.

14–36. CONNECTING TERMINAL LUGS TO TERMINAL BOARDS. (See figure 14–17). Install terminal lugs on Military Standard terminal boards MS25123 or

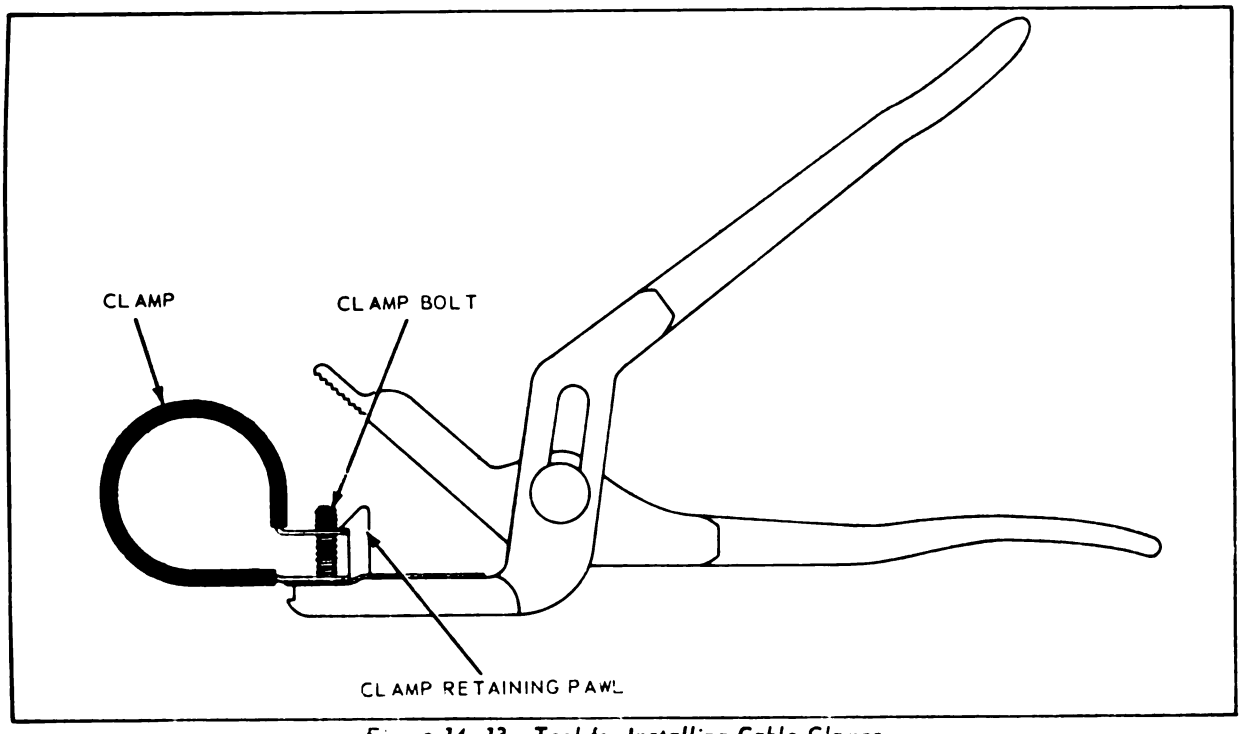


Figure 14–13. Tool for Installing Cable Clamps

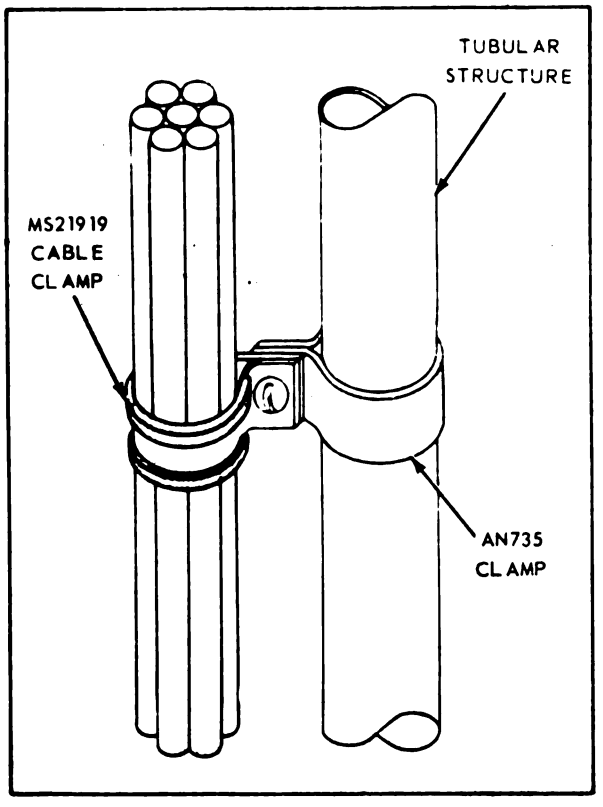


Figure 14–14. Installing Cable Clamps to Tubular Structure

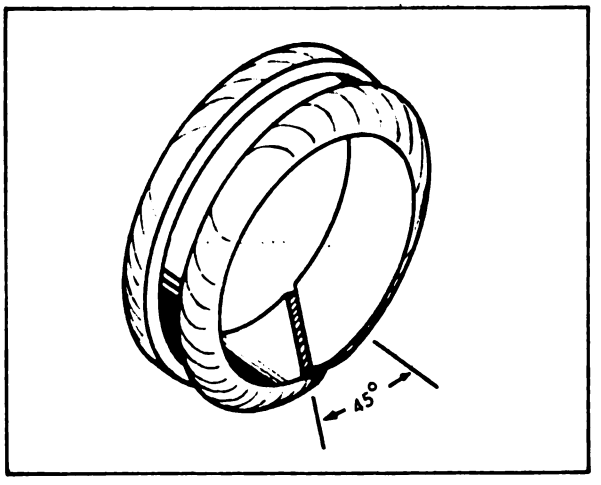


Figure 14–15. Split Grommet

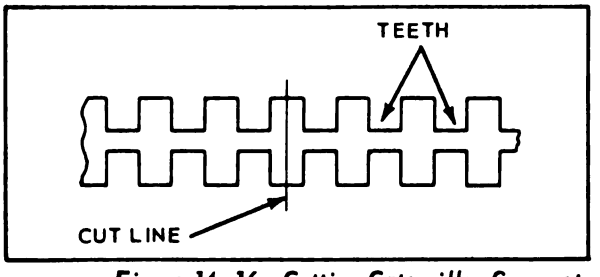


Figure 14–16. Cutting Caterpillar Grommet

MS27212 in such a way that they are locked against movement in the direction of loosening. See table 14–4 for MS27212 terminal board specifications.

Note

MS27212 terminal boards are used in Navy and Air Force installations as a replacement for the NAS 191 terminal boards formerly used. MS25123 are also used in Navy installations.

14–37. HARDWARE FOR WIRING TERMINAL BOARDS. MS25123 terminal boards have studs secured in place with an AN960 flat washer and an MS20341 steel nut. Place COPPER terminal lugs directly on top of the MS20341 nut. Follow with an AM960 flat washer, an AN935 split steel lockwasher, and either an MS20341 steel nut or an MS21044 self-locking all-metal nut. See figure 14–18 for details of this assembly.

Note

Do not eliminate the AN935 split lock-washer even when using an MS21044 self-locking nut.

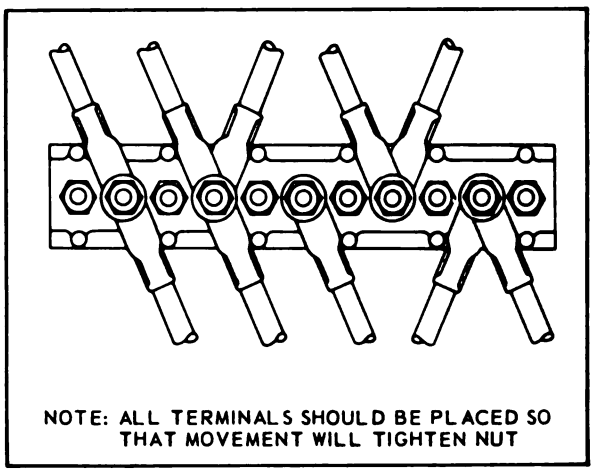


Figure 14–17. Connecting Terminals to Terminal Board

TABLE 14–4

MS27212 Terminal Boards and Covers

Terminal Board MS Part Number	Stud Thread	Number of Studs	Cover Part Number
MS27212–1–20	6–32UNC–2A	20	MS18029–1–20
MS27212–2–16	10–32UNF–2A	16	MS18029–2–16
MS27212–3–8	1/4–28UNF–2A	8	MS18029–3–8
MS27212–4–8	5/16–24UNF–2A	8	MS18029–4–8
MS27212–5–8	3/8–24UNF–2A	8	MS18029–5–8

Note: Terminal boards and covers are procured in full lengths with number of studs indicated. Cut to suit needs at installation.

14–38. MS27212 terminal boards have studs molded in, so do not require hardware for attaching studs to the terminal board. Use same hardware for installing terminal lugs as for MS25123 terminal boards (refer to 14–37 and figure 14–18.)

14–39. Place ALUMINUM terminal lugs over an MS25440 plated flat washer of the correct size for terminal and stud from table 14–5. Follow the terminal lugs with another MS25440 flat washer, an AN935 split steel lock-washer and either an MS20341 nut or an MS21044 self-locking all-metal nut. See figure 14–19 for details of this assembly.

CAUTION

Do not place *any* washer in the current path between two aluminum terminal lugs or between two copper terminal lugs.

CAUTION

Never place a lockwasher directly against the tongue or pad of an aluminum terminal or busbar.

14–40. To join a COPPER terminal lug to an ALUMINUM terminal lug, place an MS25440 flat washer over the nut which holds the stud in place; follow with the ALUMINUM terminal lug, another MS25440 washer, the COPPER terminal lug, AN960 plain washer, AN935 split steel lockwasher and MS20341 plain nut or MS21044 self-locking nut. See figure 14–20 for details.

TABLE 14–5

Washers for use with ALUMINUM Terminal Lugs

MS Number	Terminal Size	Stud Size
MS25440–3	8, 6, 4	No. 10
–4	8, 6, 4, 2, 1, 1/0	1/4
–5	8, 6, 4, 2, 1, 1/0, 2/0	5/16
–6	8, 6, 4, 2, 1, 1/0, 2/0	3/8
–6A	3/0, 4/0	3/8
–8	2, 1, 1/0, 2/0, 3/0, 4/0	1/2

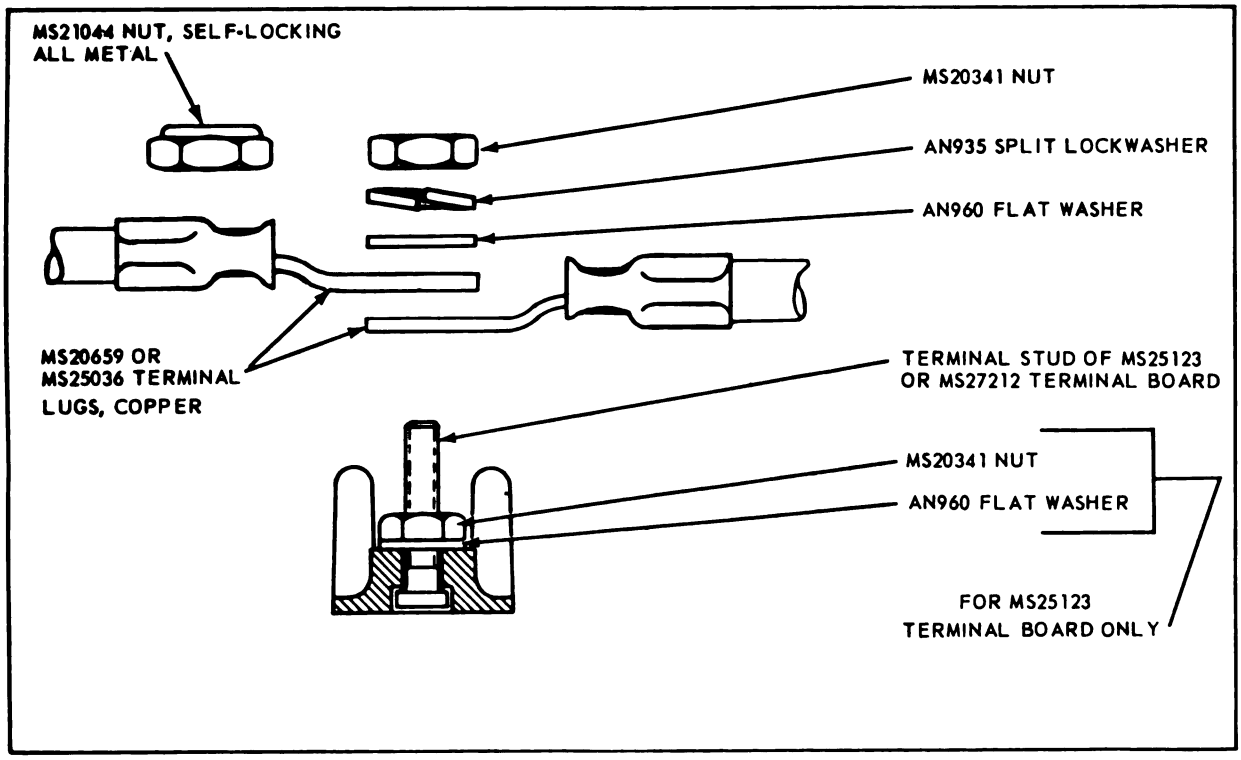


Figure 14–18. Hardware for Wiring Terminal Boards with Copper Terminals

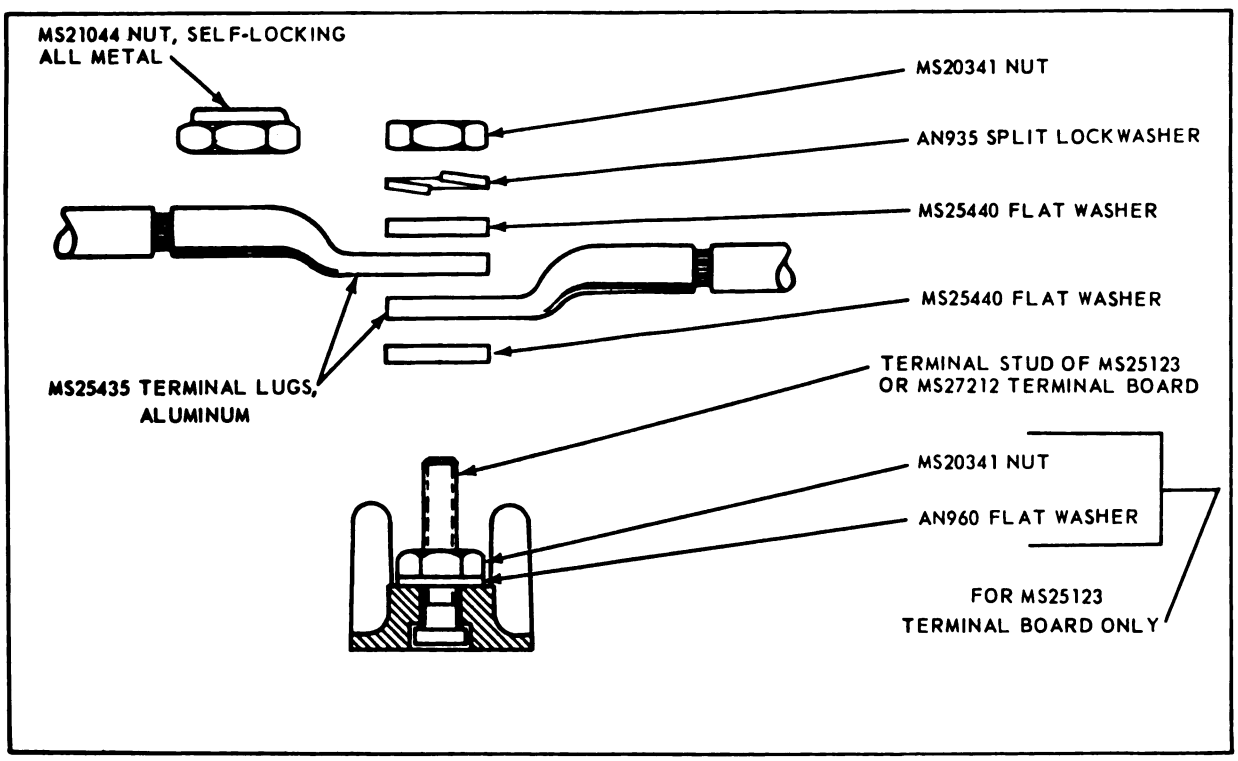


Figure 14–19. Hardware for Wiring Terminal Boards with Aluminum Terminals

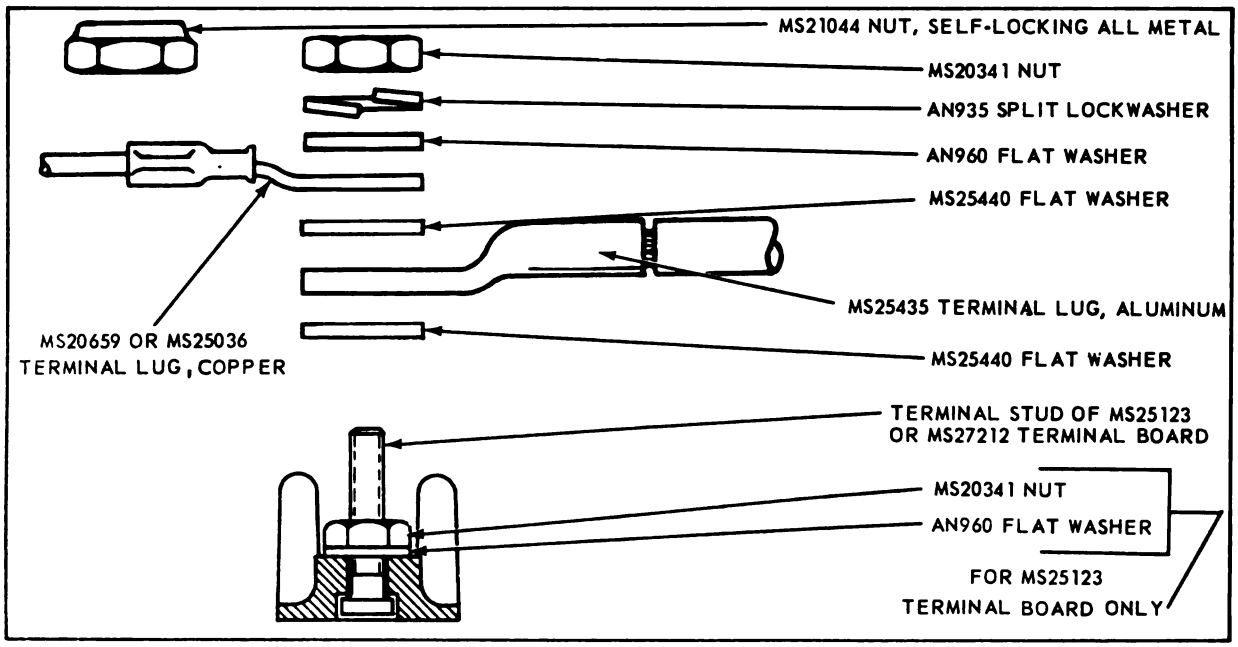


Figure 14–20. Hardware for Wiring Terminal Boards with Combination of Terminals

14–41. INSTALLATION TORQUES FOR LARGE COPPER TERMINALS. Use a torque wrench to tighten nuts on 3/8" and larger diameter studs to insure sufficient contact pressure. The tightening torques for steel studs are as listed in table 14–6.

TABLE 14–6

Installation Torques for Copper Terminal

	Inch-Pounds of Torque	
Stud Size	Plain Nuts	Self-locking Nuts
3/8–24	110–120	115–125
1/2–20	135–150	150–170

14–42. INSTALLATION TORQUES FOR ALUMINUM TERMINALS. Use a torque wrench to tighten nuts over any stack-up containing an ALUMINUM terminal lug. The tightening torques for steel studs are listed in ble 14–7.

TABLE 14–7

Installation Torques for Aluminum Terminals

Stud Size	Inch-Pounds of Torque
#10	32
1/4	100
5/16	150
3/8	250
1/2	480

14–43. CONNECTING TERMINAL LUGS TO BUSBARS. In order to obtain maximum efficiency in the transfer of power, the terminal lug and the busbar should be in direct contact with each other, so that the current does not have to go through any of the attaching parts, even if these are good-current-carrying materials. As illustrated in figures 14–21 through 14–24 the above applies whether the terminal lugs and the busbar are of the same or of different materials.

14–44. CLEANING BUSBARS WHEN MAKING CONNECTIONS. Clean all busbar areas before making new connections or replacing old connections. See Section XIII for procedure to be followed in cleaning busbars. As noted in paragraph 13–9, the cleaned surface of an ALUMINUM busbar is coated with a petrolatum-zinc dust compound which is left on the surface while the connection is made.

14–45. HARDWARE FOR CONNECTION TO BUSBARS. *Cadmium* plated steel hardware (except as noted below) is used to secure terminals to busbars. Use split lockwashers under hex nuts and under self-locking nuts. Use plated steel plain washers between lockwashers and copper terminals. Use plated brsss flat washers (MS25440) between lockwashers and aluminum terminals. As shown in figures 14–21 through 14–24, the head of the screw or bolt can be located on the terminal side or the busbar side as required to simplify the installation.

14–46. Use a cadmium plated steel split lockwasher (AN935) under the head of every bolt or screw and also under the nut, as shown.

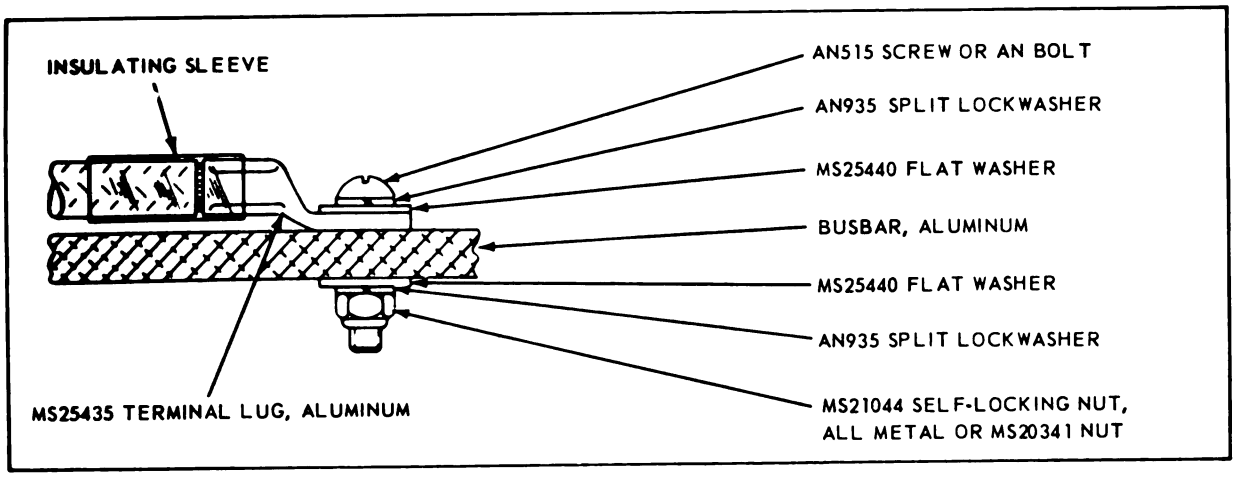


Figure 14–21. Connecting Aluminum Terminal to Aluminum Busbar

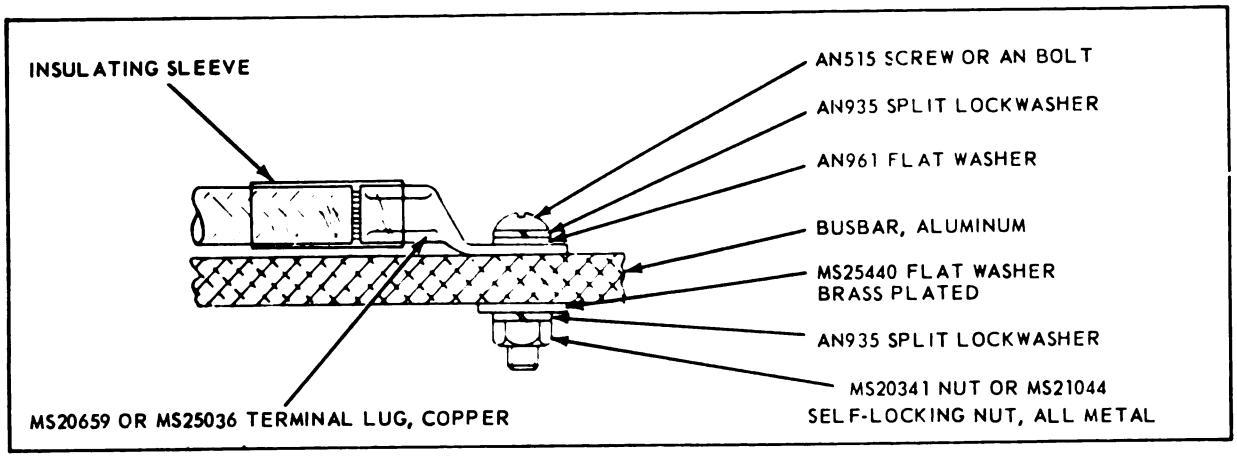


Figure 14–22. Connecting Copper Terminal to Aluminum Busbar

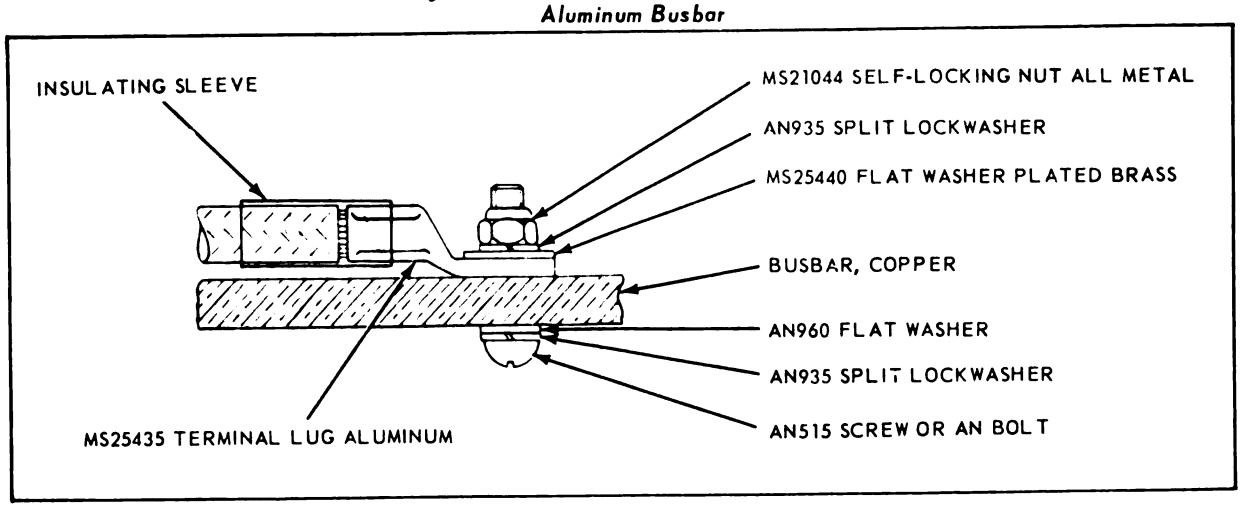


Figure 14–23. Connecting Aluminum Terminal to Copper Busbar

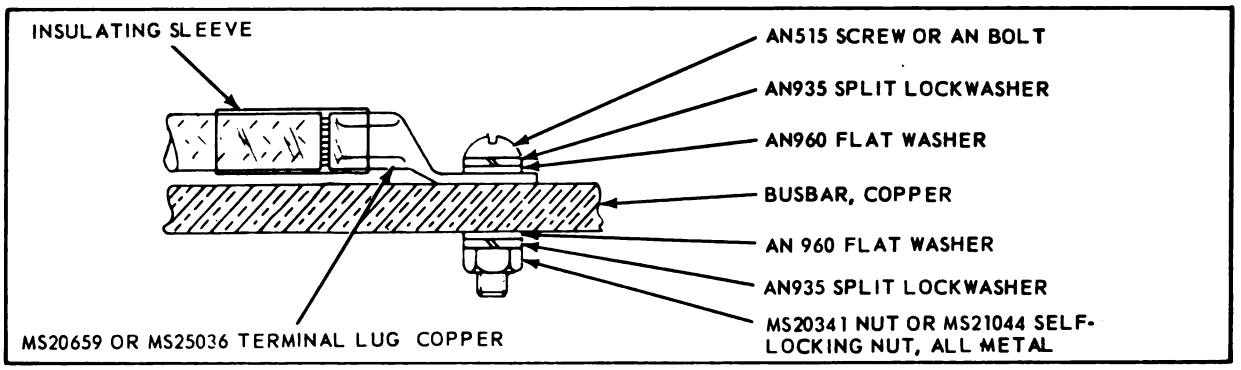


Figure 14–24. Connecting Copper Terminal to Copper Busbar

14–47. Use plated brass flat washers (MS25440) in contact with aluminum. The washer diameter must be at least equal to the tongue diameter of the terminal. See table 14–5. Do not select a washer so large that it will ride on the barrel of the terminal. After tightening connection use soft cloth to wipe off excess petrolatum-zinc compound left in place in accordance with 14–44.

14–48. PRECAUTIONS WHEN REPLACING EXISTING CONNECTIONS. Observe the following precautions when replacing existing terminal lug connections to busbars.

a. Check all flat washers. Replace bent washers. Replace washers which have scratched plating or paint on faying surface.

b. Clean busbar connection areas by approved methods. (See Section XIII).

c. Check plated copper terminal lugs before connecting to an aluminum busbar. If plating is scratched, replace terminal lug.

14–49. CONNECTING TWO TERMINALS TO SAME POINT ON BUSBAR. Terminal lugs must always be in direct contact with busbar. As shown in figure 14–25, connect one terminal lug to top of busbar and the other to bottom.

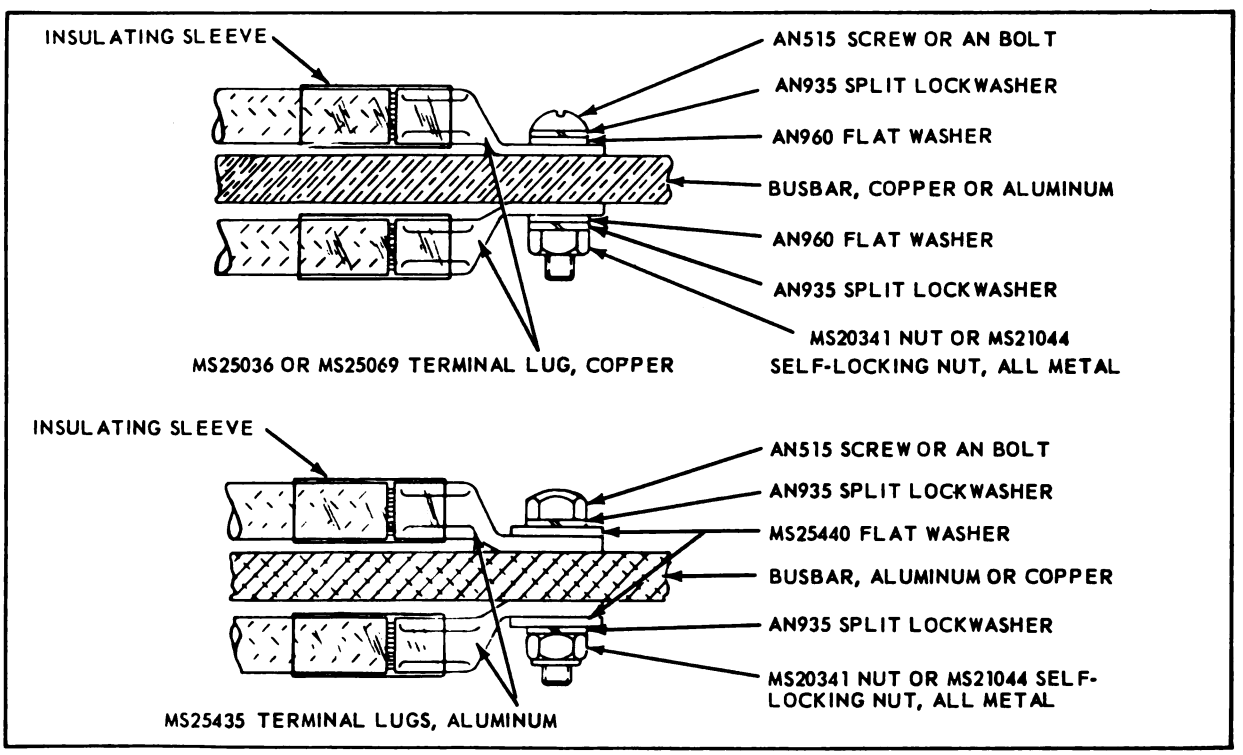


Figure 14–25. Connecting Two Terminals to Same Point on Busbar

Note

Terminal lug offset is positioned so that barrel cannot contact busbars. This allows proper seating of tongue on busbar.

14–50. PROTECTION OF BUSBARS AGAINST ACCIDENTAL SHORTING. Busbars are usually enclosed in panels or junction boxes to protect them against accidental shorting. If the busbars are not enclosed it is desirable to use some protective coating. A good protective coating which is easily applied is MIL-S-8516 Sealing Compound. This is applied thickly with a spatula or short bristled brush to the cleaned busbar prior to assembly of connections. Mask all areas where connections will be made. Use pressure sensitive tape for masking. See detailed instructions for applying and curing sealing compound in section X and in section III, paragraph 3–62. Remove masking tape after sealing compound is cured by cutting into compound next to tape with a razor blade and peeling tape from the masked area.

15–51. Busbars can also be protected by slitting a piece of vinyl rubing and wrapping it around the busbar after all connections are made. Select vinyl tubing which has large enough diameter to permit a generous overlap when tying it in place. See figure 14–26 for cutting and tying details.

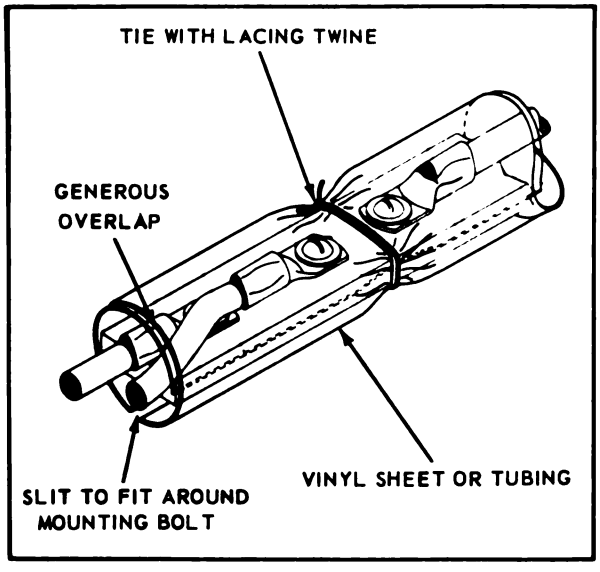


Figure 14–26. Vinyl Tubing Around Busbar

14–52. CONNECTING TERMINAL LUGS TO EQUIPMENT. When connecting wired terminal lugs to terminals on switches, relays and other equipment, the terminal lugs may be bent at the barrel-tongue junction if necessary to permit installation. When bending is required, keep the bend radius as *large* as possible, while keeping the bend angle as *small* as possible.

CAUTION

Do not bend terminal lugs to an angle greater than 90 degrees. Do not subject terminal lugs to more than one bending operation,

13–53. INSTALLATION OF WIRES IN CONDUIT.

14–54. CONDUIT CAPACITY. Measure the bundle wires before installing in conduit. In accordance with Military Specification MIL-W-5088 the bundle diameter must not exceed 80% of the internal diameter of the conduit. See figure 14–27.

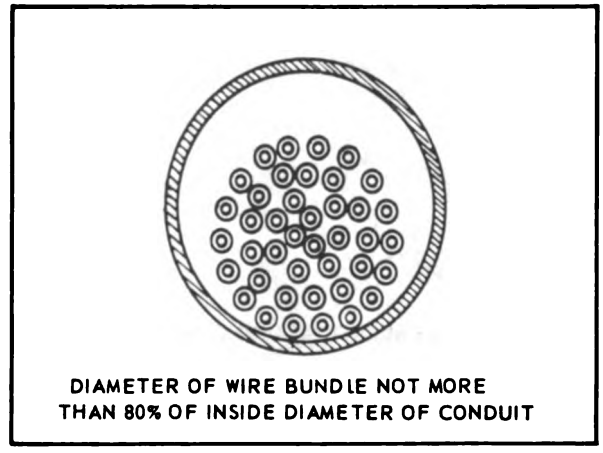


Figure 14–27. Conduit Capacity

CAUTION

No ties or splices are permitted insiee a conduit.

14–55. FEEDING WIRES INTO CONDUIT. Feed wires through a short length of conduit by taping the end of the bundle together and pushing it gently through. Longer runs of conduit or conduit with complex bends will require a leader. Make a leader out of a flannel or other soft cloth patch attached to a string long enough to pass completely through the conduit. The patch should fit loosely in conduit. See figure 14–28. Use compressed air at no more than 35 psi to blow patch and attached string through the conduit. Tie wire bundle securely to string and tape over junction to cover all wire ends. Pull string through conduit while carefully feeding wires into other end. After wire is installed remove tape and detach string.

14–56. SUPPORTING WIRES AT END OF RIGID CONDUIT. Use an MS21919 cable clamp to support wires at each end of conduit. Place the cable clamp in a direct line with the conduit end to prevent chafing of wires at edge of conduit. Place cable clamp as close to end of conduit as practicable, but never more than 10 inches away. See figure 14–29.

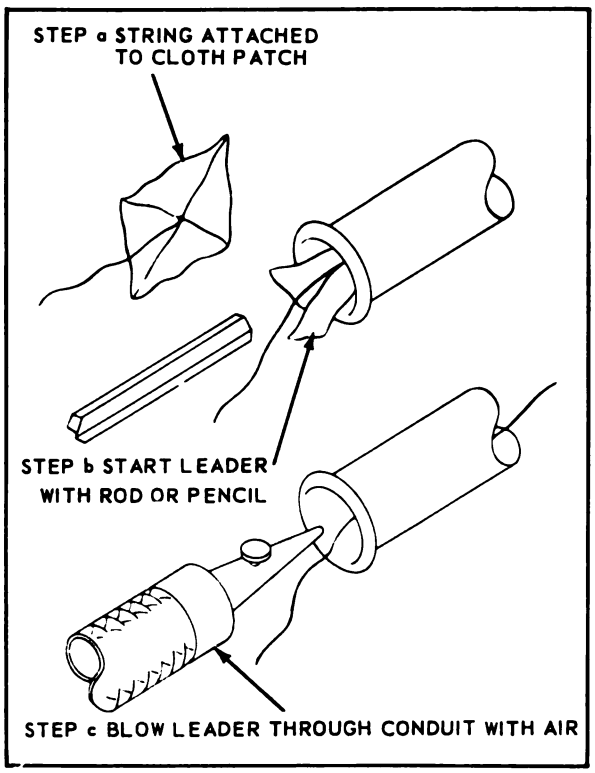


Figure 14–28. Leader for Conduit

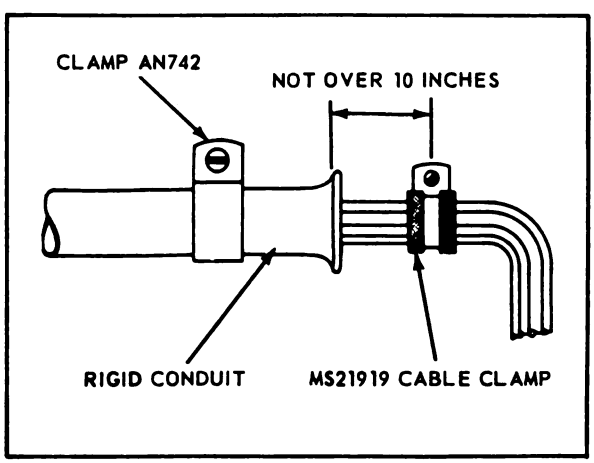


Figure 14–29. Support for Wire at Conduit End

Note

Do not leave wire slack inside conduit. Wires should be free but not taut inside conduit.

14–57. INSTALLATION OF CONNECTORS.

14–58. ASSEMBLY OF CONNECTORS TO RECEPTACLES. Assemble connectors to receptacles as follows:

CAUTION

Do not use force to mate connectors to receptacles.

a. Locate the proper position of the plug in relation to the receptacle by aligning the key of one part with the groove or keyway of the other part.

CAUTION

Do not twist wire bundle excessively to achieve proper matching of plug and receptacle.

b. Start the plug into the receptacle with a light forward pressure and engage the threads of coupling ring and receptacle.

c. Alternately push in the plug and tighten the coupling ring until the plug is completely seated.

CAUTION

Do not hammer a plug into its receptacle. Never use a torque wrench, or pliers to lock coupling rings.

d. Use a strap wrench to tighten coupling rings 1/16 to 1/8 turn beyond finger tight if space around connector is too small to obtain a good finger grip.

14–59. DISASSEMBLY OF CONNECTORS FROM RECEPTACLES. Disassemble connectors as follows:

a. Use strap wrench to loosen coupling rings which are too tight to be loosened by hand.

b. Alternately pull on the plug body and unscrew coupling ring until connector is separated.

CAUTION

Do not pull on attached wires.

c. Protect disconnected plugs and receptacles with caps to keep debris from entering and causing faluts.

14–60. CODING OF CONNECTORS. As a design objective, receptacles whose plugs are interchangeable are not located in close proximity to each other. However, when installation requirements are such that these receptacles are in adjacent locations use clamps on the plug wires, or assemble plugs and receptacles so as to use one of the alternate insert positions, to make it physically impossible to connect a plug into the wrong receptacle. Also color-code the connector plug body and the flange or mounting area of the receptacle.

a. Use one bright color, such as red, green or yellow for each matching pair.

b. Paint only the shell of plugs - not the coupling rings.

c. Paint only the mounting flange of the receptacle.

Note

Avoid painting the threaded surfaces or insulators of plugs or receptacles.

14–61. SPECIAL PRECAUTIONS FOR CONNECTORS WITH RESILIENT INSERTS. When assembling or installing miniature MS connectors with resilient inserts, observe the following special precautions:

a. Before mating connectors, inspect to see that contacts are not splayed or bent. When mating connectors make sure that plug is inserted *straight* into the receptacle before tightening coupling ring.

b. Avoid, where possible, locating connectors of the same shell size adjacent to each other, whether they have different insert arrangements or not.

c. Locate receptacles where they are clearly visible and accessible to aid in keying and inserting plug. This will help to avoid bending receptacle pins while seeking proper polarization.

CAUTION

Do not mis-connect plugs and receptacles by forcing pins into the resilient insert, either by misalignment of properly mating connectors, or by joining connectors with identical shells but differently keyed insert arrangements.

d. When mating connectors with bayonet lock coupling, make sure that *all* locking rivets of the coupling are engaged.

14–62. MOUNTING CONNECTORS. Before mounting receptacles to the back of a panel or bulkhead, make sure there is sufficient clearance to couple the plug to the receptacle. Make sure that mounting hardware does not interfere with the installation of the locking ring.

14–63. INSTALLING CONDUIT ON CONNECTORS. When installing a stepped-down conduit on the back shell of a connector having large wires (size No. 8 or larger), add an additional back shell to the connector before installing the conduit. This will allow the wire bundle to decrease in diameter gradually, and prevent sharp bends in the wires. (See figure 14–30.)

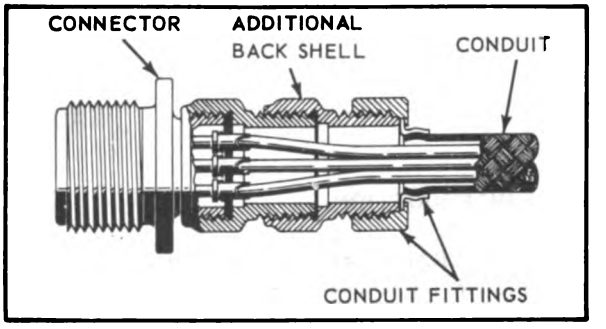


Figure 14–30. Installing Conduit on Connector Back Shell

14–64. INSTALLATION OF WIRE IN JUNCTION BOXES.

14–65. LACING OR TYING IN JUNCTION BOXES. Wire bundles can be either laced or tied with spot ties. Lacing and tying procedures are described in section XV.

14–66. SUPPORT INSIDE JUNCTION BOXES. Use MS21919 cable clamps to support wires across hinged doors to that wires will be twisted and not bent when the door is opened. See figure 14–31 for correct and incorrect methods of support.

14–67. Attach wire bundles to walls of junction box to prevent chafing or abrasion against terminal studs or other items in box. Tie up slack (required for terminal rework) to prevent snagging.

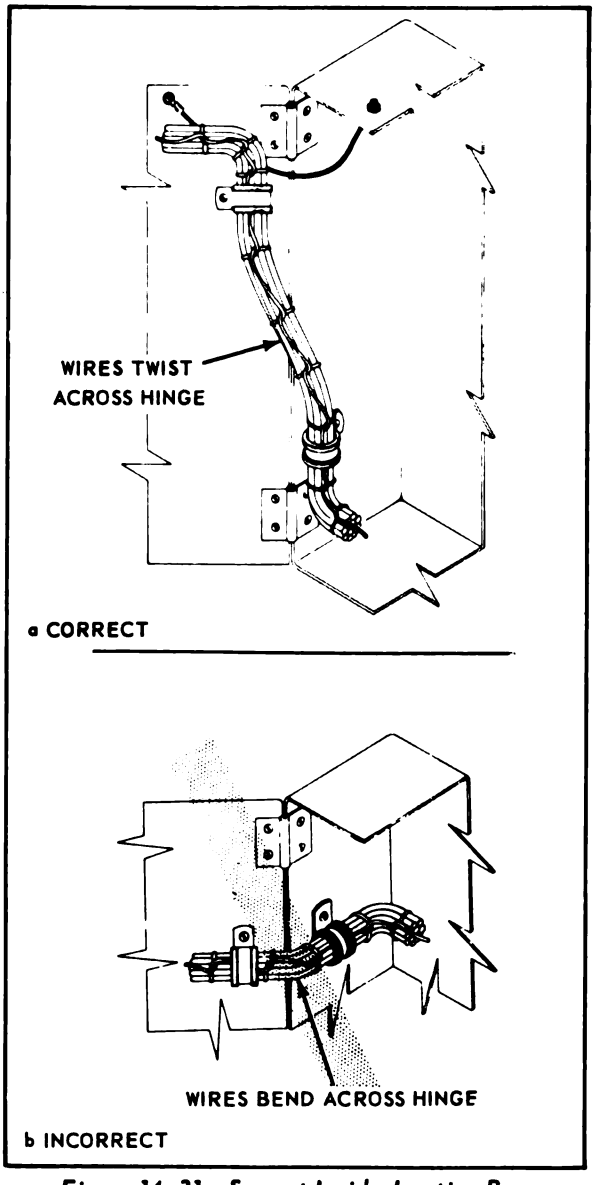


Figure 14–31. Support Inside Junction Box

SECTION XV

LACING AND TYING

15–1. INTRODUCTION.

15–2. GENERAL. Wire groups and bundles are laced or tied to provide ease of installation, maintenance and inspection.

15–3. SCOPE. This section describes and illustrates the recommended procedures for lacing and tying wire groups or bundles, using knots which will hold tightly under all conditions; and for installing self-clinching plastic cable straps. Serving of wire is described in Section VII, paragraph 7–24.

15–4. REFERENCE SPECIFICATIONS AND DRAWINGS.

MIL-S-572	Cords, Yarns and Monofilaments, Organic Synthetic Fiber
MIL-T-713	Twine and Tape, Lacing and Tying, for Use in Electrical and Electronic Equipment
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-C-5649	Cord, Cotton, Braided, Prewaxed
MIL-I-7798	Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic
MIL-S-23190	Strap, Cable, Adjustable, Plastic
MS17821	Strap, Cable, Adjustable, Self-Clinching, Plastic
MS17822	Strap, Cable, Identification, Adjustable, Self-Clinching, Plastic
MS17823	Tool, Hand, for Adjustable Plastic Cable Straps, Thin Type
MS17824	Tool, Hand, for Adjustable Plastic Cable Straps, Thick Type

15–5. DEFINITIONS.

a. Tying is the securing together of a group or bundle of wires with individual ties at regular intervals around the group or bundle.

b. Lacing is the securing together of a group or bundle of wires, installed inside enclosures, by means of a continuous cord forming loops at regular intervals around the group or bundle.

c. A Wire Group is two or more wires tied or laced together to give identity to an individual system.

d. A Wire Bundle is two or more wires or groups tied or laced together to facilitate maintenance.

15–6. MATERIALS. Use narrow flat tape wherever possible for lacing and tying. Round cord may also be used, but its use is not preferred because cord has a tendency to cut into wire insulation. Use cotton, linen, nylon or glass fiber cord or tape, according to temperature requirements. Cotton or linen cord or tape must be prewaxed to make it moisture and fungus resisting. Nylon cord or tape may be waxed or unwaxed; glass fiber cord or tape is usually not waxed.

CAUTION

Use only flat braided waxed nylon tape to lace or tie coaxial cables, or bundles containing coaxial cables.

15–7. Use either vinyl or glass fiber pressure-sensitive tape, according to temperature requirement. Use pressure-sensitive tape only when its use is specifically permitted.

15–8. Molded nylon self-clinching cable straps may be used where the temperature is not expected to exceed 350°F.

15–9. GENERAL PRECAUTIONS. When lacing or tying wire groups or bundles, observe the following precautions:

a. Lace or tie bundles tightly enough to prevent slipping, but not so tightly that the cord or tape cuts into or deforms the insulation. Be especially careful when lacing or tying coaxial cable, which has a soft dielectric insulation between the inner and outer conductors.

CAUTION

Do not use round cord for lacing or tying bundles which contain coaxial cable.

b. Do not use ties on that part of a wire group or bundle located inside a conduit.

c. When tying wire bundles behind connectors, start ties far enough back from the connector to avoid splaying of contacts.

15–10. LACING. Continuous lacing may be used only on those wire groups or bundles which are to be installed in panels or junction boxes. Use double cord lacing on groups or bundles larger than one inch in diameter. Use either single or double cord lacing on groups or bundles one inch or less in diameter. For lacing groups which branch off a main bundle, see 15–13.

Note

When lacing wire groups or bundles observe precautions listed in 15–9.

15–11. SINGLE CORD LACING. Lace a wire group or bundle with a single cord as follows: (See figure 15–1).

a. Start the lacing at the thick end of the wire group or bundle with a knot consisting of a clove hitch with an extra loop.

b. At regular intervals along the wire group or bundle, and at each point where a wire or wire group branches off, continue the lacing with half hitches.

Note

Space half hitches so that the group or bundle is neat and securely held.

c. End the lacing with a knot consisting of a clove hitch with an extra loop.

d. Trim the free ends of the lacing cord to 3/8 inch minimum.

15–12. DOUBLE CORD LACING. Lace a wire group or bundle with a double cord as follows: (See figure 15–2).

a. Start the lacing at the thick end of the wire group or bundle with a bowline on a bight.

b. At regular intervals along the wire group or bundle, and at each point where a wire group branches off, continue the lacing with half hitches, holding both cords together.

Note

Space half hitches so that the group or bundle is neat and securely held.

c. End the lacing with a knot consisting of a half hitch, using one cord clockwise and the other counterclockwise, and then tying the cord ends with a square knot.

d. Trim the free ends of the lacing cord to 3/8 inch minimum.

15–13. LACING BRANCH-OFFS. Lace a wire group that branches off the main wire bundle as follows: (See figure 15–3).

a. Start the branch-off lacing with a starting knot located on the main bundle just past the branch-off point. When single cord lacing is used, make this starting knot as described in 15–11, step a; and when double cord lacing is used, make it as described in 15–12, step a.

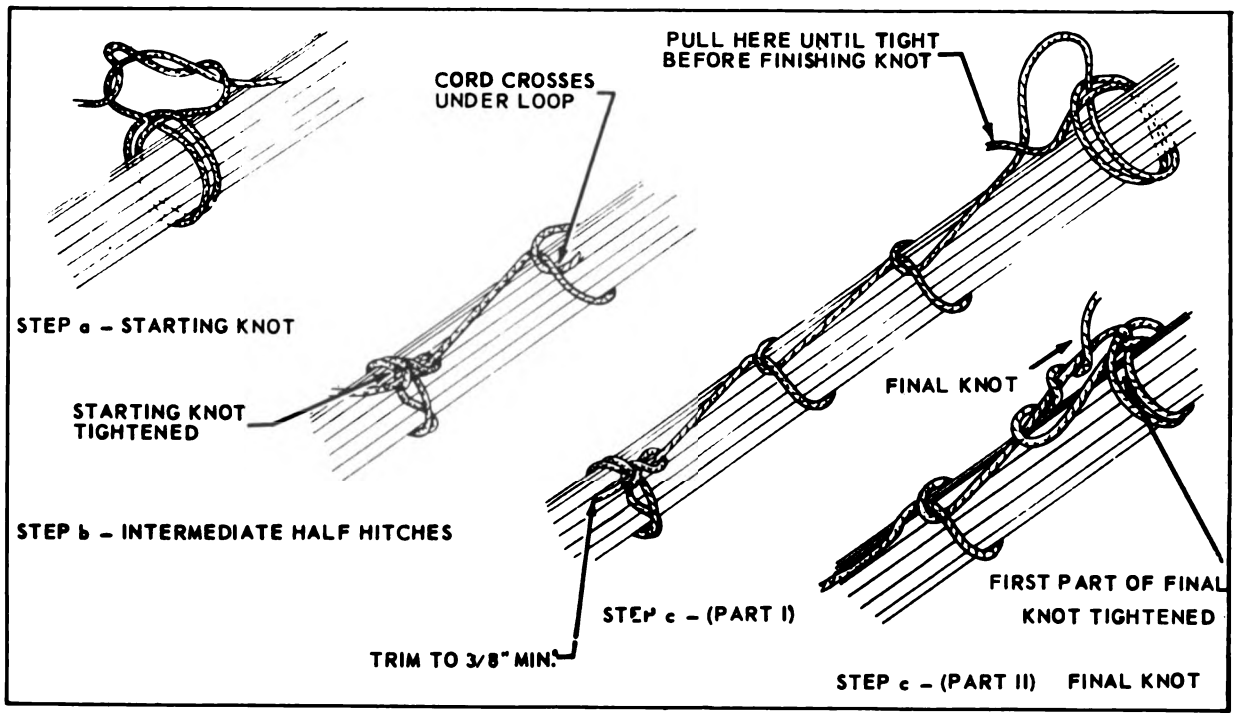


Figure 15–1. Single Cord Lacing

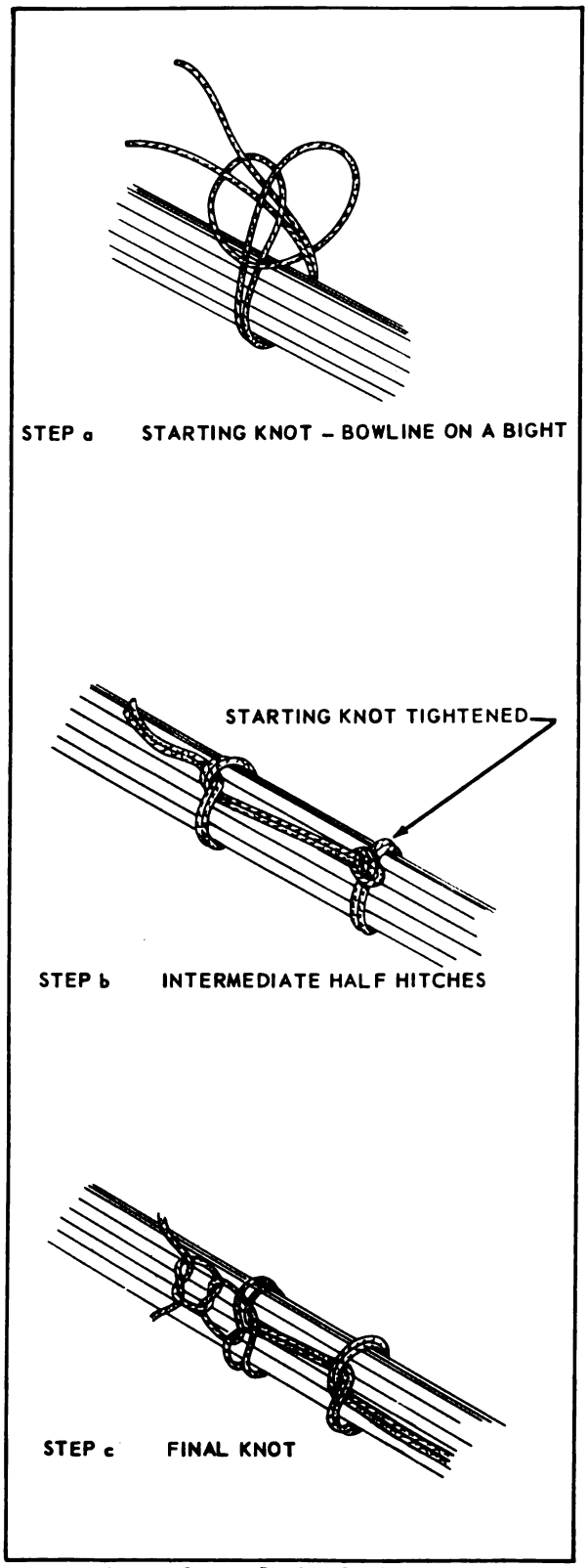


Figure 15–2. Double Cord Lacing

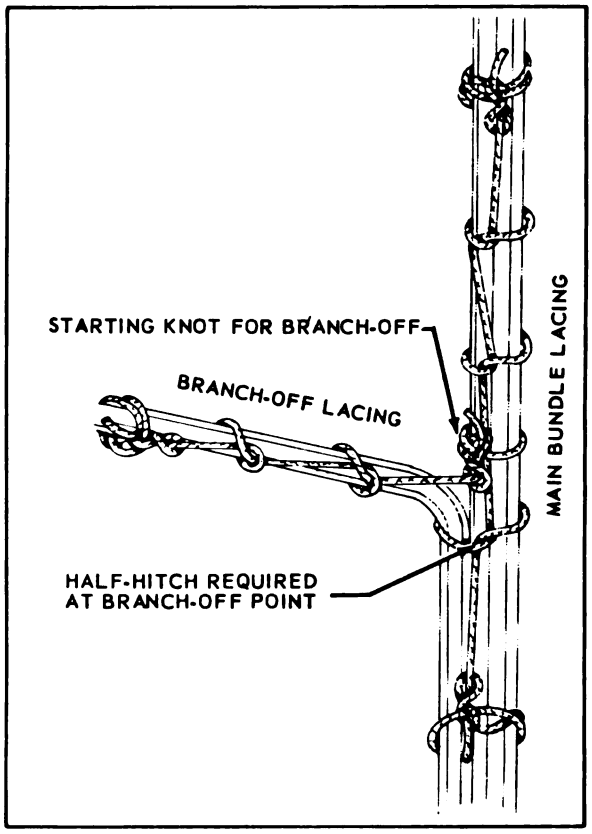


Figure 15–3. Lacing a Branch-Off

b. Continue the lacing along the branched-off wire group, using regularly spaced half hitches. Where a double cord is used, both cords are held together.

Note

Space half hitches so that the group or bundle is neat and securely held.

c. End the lacing with the regular knot used in single and double cord lacing, as described in 15–11, step c, and 15–12, step c, respectively.

d. Trim the free ends of the lacing cord to 3/8 inch minimum.

15–14. TYING. Tie all wire groups or bundles where supports are more than 12 inches apart. Space ties 12 inches or less apart.

15–15. MAKING TIES. Make tie as follows:

a. Wrap cord around wire group or bundle, as shown in figure 15–4.

b. Make a clove hitch, followed by a square knot with an extra loop.

c. Trim free ends of cord to 3/8 inch minimum.

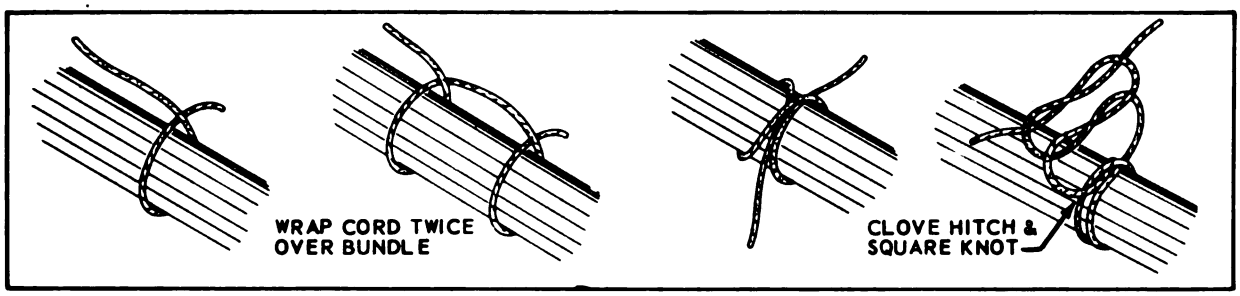


Figure 15–4. Making Ties

15–16. TEMPORARY TIES. Temporary ties are used to aid in making up and installing wire groups or bundles. Use colored cord to make temporary ties, and remove these ties when the installation is complete.

CAUTION

Cut temporary ties with scissors or diagonal pliers only. Do not use a knife or other sharp edged instrument which may damage the insulation.

15–17. TYING WIRE GROUPS INTO WIRE BUNDLES. Tie wire groups into bundles as described in 15–15, treating the wire groups as though they were individual wires.

15–18. TYING SLEEVES TO WIRE GROUPS OR WIRE BUNDLES. Secure sleeves to wire groups or bundles by tying as described in 15–15.

15–19. SECURING WITH PRESSURE-SENSITIVE TAPE. See figure 15–5. When use of pressure-sensitive tape is permitted, install the tape as follows:

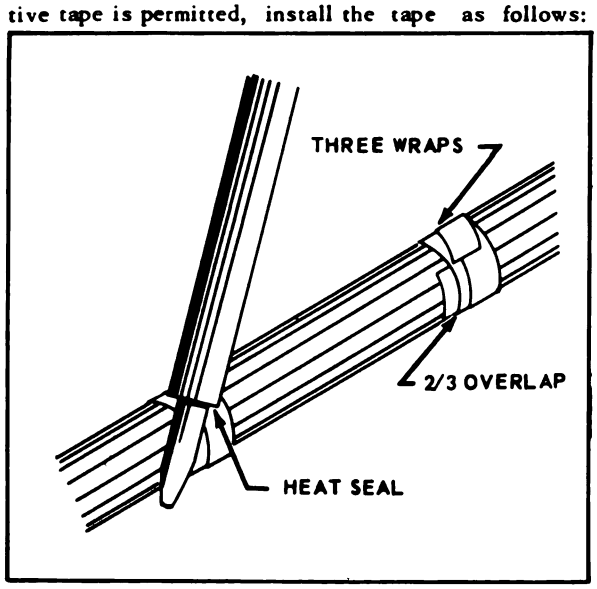


Figure 15–5. Securing with Tape

a. Wrap tape around wire group or bundle three times, with a two-thirds overlap for each turn.

b. Heat-seal the loose tape end with the side of a soldering iron heating element.

CAUTION

Do not use tape for securing wire groups or bundles which may require frequent maintenance.

15–20. SELF-CLINCHING CABLE STRAPS. These are adjustable lightweight flat nylon straps, with molded ribs or serrations on the inside surface to grip the wire. They may be used instead of individual cord ties for fast securing of wire groups or bundles. The straps are of two types: MS17821, a plain cable strap, and MS17822, similar to MS17821, but with the addition of a flat surface for identification marking. Refer to section II for use of cable straps to identify wire bundles. Both types of cable straps are available in ten colors as listed in table 15–1.

TABLE 15–1

Cable Strap Colors

Color Dash No.	Color
–0	Black
–1	Brown
–2	Red
–3	Orange
–4	Yellow
–5	Green
–6	Blue
–7	Purple
–8	Gray
–9	Natural

15–21. INSTALLING SELF-CLINCHING CABLE STRAPS. Use the Military Standard hand tools listed in table 15–2 to install plastic cable straps on wire bundles. The procedure is as follows: (See figure 15–6.)

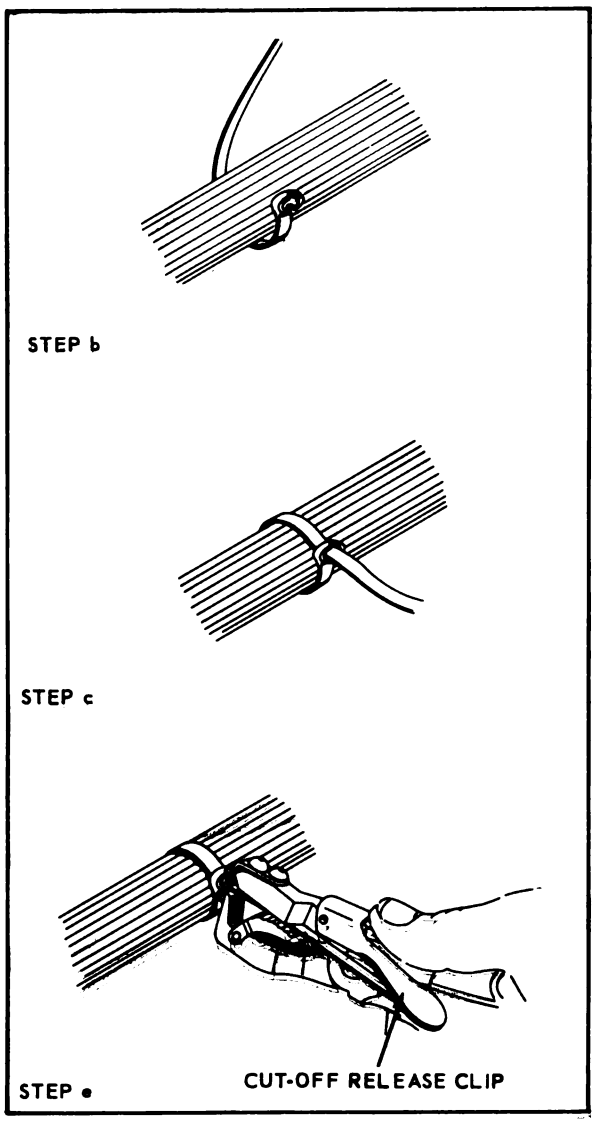


Figure 15–6. Installing Self-Clinching Cable Strap

a. Select a strap of the desired color for the application, and of a size suitable for the wire bundle from table 15–2.

b. Slip the plastic strap around the bundle, with the ribbed side in.

c. Thread the tip of the strap through the eye in the strap boss, and pull the strap tight around the bundle.

d. Select the proper tool for the strap used from table 15–2.

e. Pass the free end of the strap through the slot in the top of the tool, and push the tool snug against the strap boss.

f. Hold the tool firmly against the boss, and pump the tool handles gently until the strap feels tight in the tool and snug abound the bundle.

g. Press the cut-off release clip, and close the tool handles all the way.

Note

Tool MS17824 does not have a cut-off release clip; the excess strap is automatically removed when the tool handles are closed.

TABLE 15–2

Self-Clinching Plastic Cable Straps and Installing Tools

MS Part No.	Type	For Bundle Dia (Inches)	MS Tool No.
MS17821–1	Thin	1/16 – 1-3/4	MS17823
MS17821–2	Thin	1/16 – 4	MS17823
MS17821–3	Thick	3/16 – 3-3/4	MS17824
MS17822–1	Thin	3/8 – 1-3/4	MS17823

SECTION XVI

WIRING; LOCK, SHEAR AND SEAL

16–1. INTRODUCTION.

16–2. GENERAL. Electric connectors, emergency, devices and other pieces of electric equipment in aircraft are secured with wire when specified on engineering drawings in order to prevent accidental loosening.

16–3. SCOPE. This section outlines the recommended procedures for wiring MS electric connectors, and emergency devices such as switches, switch guards and handles which operate ejection seats, emergency bomb releases, fire extinguishers etc. General practices for safety wiring are specified in Military Standard Drawing MS33540.

16–4. REFERENCE SPECIFICATION AND DRAWINGS.

MIL-W-5088	Wiring, Aircraft, Installation of
MS20995	Wire, Lock
MS33540	Safety Wiring, General Practices for

16–5. DEFINITIONS.

16–6. LOCK WIRE. Lock wire is a heavy twisted double-strand wire used to secure parts against inadvertent opening in all areas of high vibration such as the engine compartment. Electric connectors are lock-wired in high-vibration areas which are normally inaccessible for periodic maintenance and inspection.

16–7. SHEAR WIRE. Shear wire is a lighter, single-strand wire used to secure parts which may be subject to periodic disconnection, maintenance and inspection, or for parts which must be quickly removed.

16–8. SEAL WIRE. Seal wire is a thin, easily breakable wire used as a seal on fire extinguishers, oxygen regulators and other emergency devices which must be quickly released for use, and to indicate whether these devices have been tampered with or used.

16–9. GENERAL PROCEDURES FOR LOCK, SHEAR AND SEAL WIRING.

CAUTION

Use only *new* wire; when replacing wired electrical connectors or emergency devices, do not re-use the old wire.

16–10. LENGTH. Use wire of the shortest length that will allow accomplishment of the procedures outlined in 16–11 through 16–22.

16–11. DOUBLE TWIST LOCK WIRING. Use the double twist method of lock wiring as illustrated in figure 16–1 for all equipment in areas of high vibration, and for electrical connectors in such areas which are inaccessible.

16–12. SINGLE WIRE METHOD. Use the single wire method shown in figure 16–2 in all conditions specified for shear and seal wire as described in 16–7 and 16–8. In addition, the single wire method may be used in areas hard to reach, and for small screws in a closely spaced pattern.

16–13. TWISTING WITH PLIERS. When wire is twisted by hand, use pliers for the final twists to apply tension, and to secure ends of wire. Cut off part of wire gripped by pliers to remove rough edges.

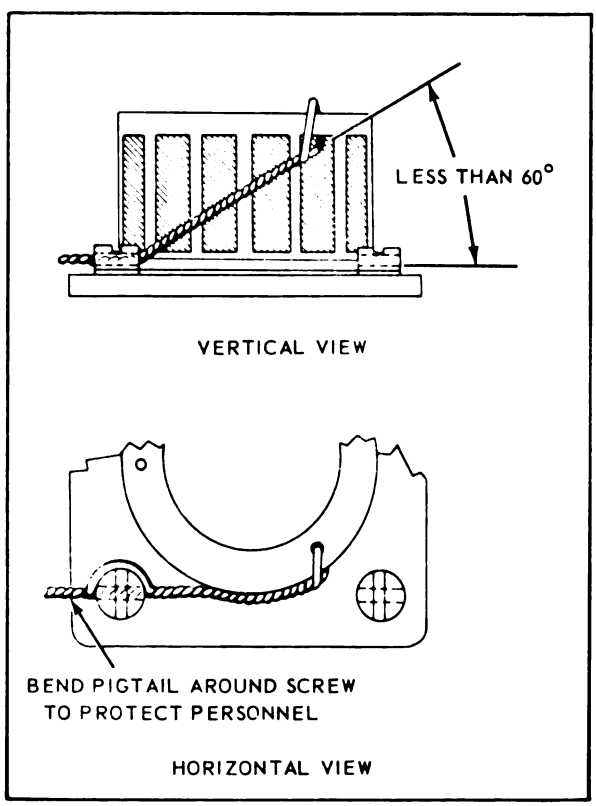


Figure 16–1. Double Twist Lock Wiring

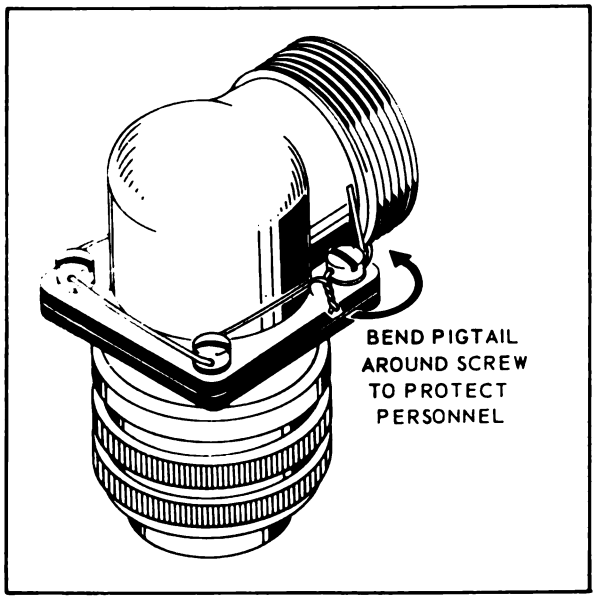


Figure 16–2. Single Wire Method

CAUTION

Make sure wire does not become kinked or nicked during twisting operation. If wire is damaged replace with new wire.

16–14. TWISTING WITH SPECIAL TOOLS. Twist wire with a wire twister as follows: (See figure 16–3.)

a. Grip wire in jaws of wire twister and slide outer sleeve down with thumb to lock handles.

b. Pull knob; spiral rod spins pliers and twists the wire.

c. Squeeze handles together to release wire.

16–15. TIGHTNESS OF WIRE. Install wire so that the wire will be in tension if the part loosens. Twist wire together so that it is tight, but do not overstress wire as it may break under load or vibration

16–16. SPECIFIC PROCEDURES FOR LOCK, SHEAR AND SEAL WIRING.

16–17. LOCK WIRING ELECTRICAL CONNECTORS. Secure electrical connectors with lock wire only when specified on engineering drawings. Electric connectors are usually lock-wired in engine nacelles, areas of high vibration and in locations not readily accessible for periodic maintenance inspection. Connectors in these locations are identified by a painted/affixed red dot 1/2 inch in diameter on adjacent aircraft structure.

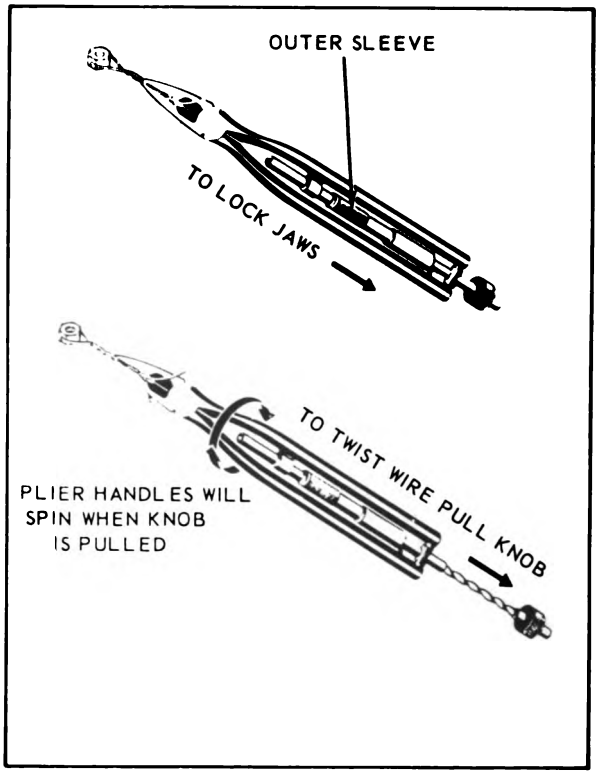


Figure 16–3. Use of Wire Twister

CAUTION

Do not wire electric or RF connectors which have a mechanical lock, as lock wiring will act against the locking feature.

16–18. LOCK WIRING AN-MS CONNECTORS. When specified on engineering drawings, lock wire AN-MS connectors as follows: (See figure 16–4.)

a. Thread lock wire through wire hole in coupling ring.

Note

If connector plug to be lock wired does not have a wire hole, remove coupling nut and drill a #56 (.046) diameter hole diagonally through the edge of nut, as shown in figure 16–5.

b. Twist wire, under slight tension, approximately 6 to 8 turns per inch, by hand, or by special tool, as described in 16–13 and 16–14. Twist wire right handed, so it will have a tightening effect.

c. Pull one end of twisted wire through hole in drilled fillister head screw on mounting flange of connector. Use a fillister head screw so located as to allow a 60° or smaller angle of the wire, as shown in figure 16–1.

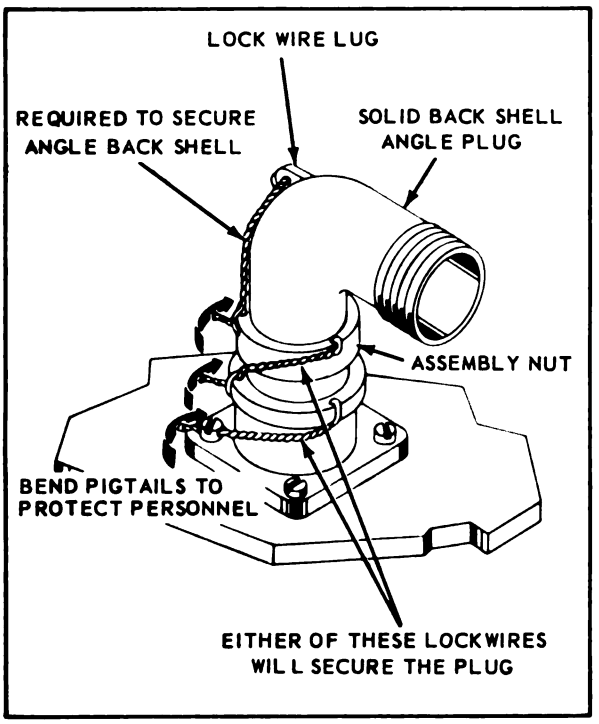


Figure 16–4. Wiring AN Type Connector

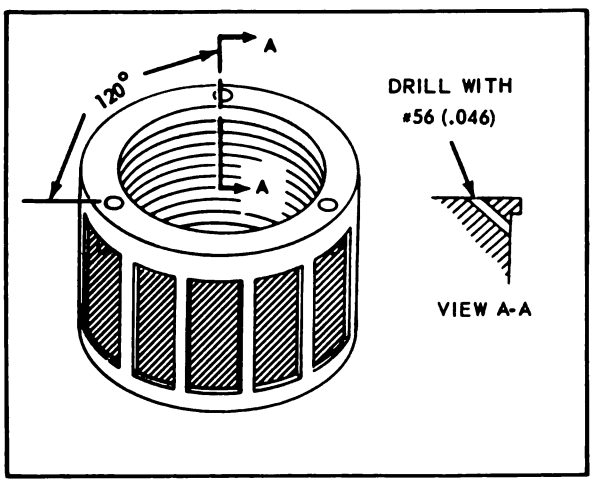


Figure 16–5. Drilling Hole in Coupling Nut

CAUTION

Do not back off or over-torque mounting fillister head screws, in order to align holes for lock wiring.

d. Form pigtail 1/4 to 1/2 inch (3 to 6 twists) with pliers.

e. Bend pigtail back toward body of connector, to prevent it from injuring personnel.

CAUTION

Lock-wire all connectors individually. Do not lock wire one connector to another.

16–19. LOCK-WIRING CONNECTOR TO STRUCTURE. If no screw is available for attaching lock wire, secure wire to drilled hole in structure not more than 6 inches from connector, as shown in figure 16–6. Use same procedure as described in 16–17.

16–20. SHEAR-WIRING SPLIT SHELL ASSEMBLIES. Split shell connectors made by Amphenol are held together by two fillister head screws. Secure these screws as follow: (See figure 16–7)

a. Draw wire through hole in one screw.

b. Cross wire from left to right between screws, and draw through second screw.

c. Twist wires together with pliers, and bend back.

16–21. WIRING SOLID SHELL ANGLE PLUGS. Angle plugs with solid back shells as made by Amphenol are in two parts, held together by four screws through mating flanges. Wire these screws with a single shear wire as shown in figure 16–2. Solid shell angle plugs made by Bendix and Cannon have back shells held in place by assembly nuts. Install a double twisted lock wire between hole in assembly nut and lug on back shell as shown in figure 16–4. If necessary to lock wire the plug itself, install a second double twisted wire between the assembly nut and the coupling nut or between the coupling nut and one of the receptacle mounting screws, as shown in figure 16–4.

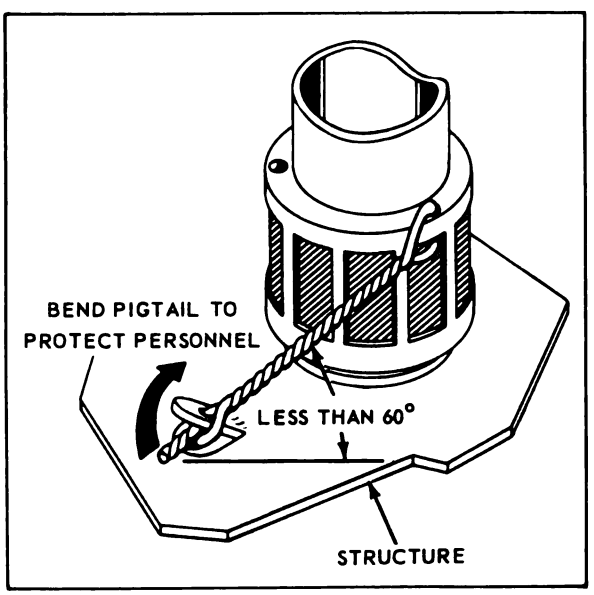


Figure 16–6. Lock Wiring Connector to Structure

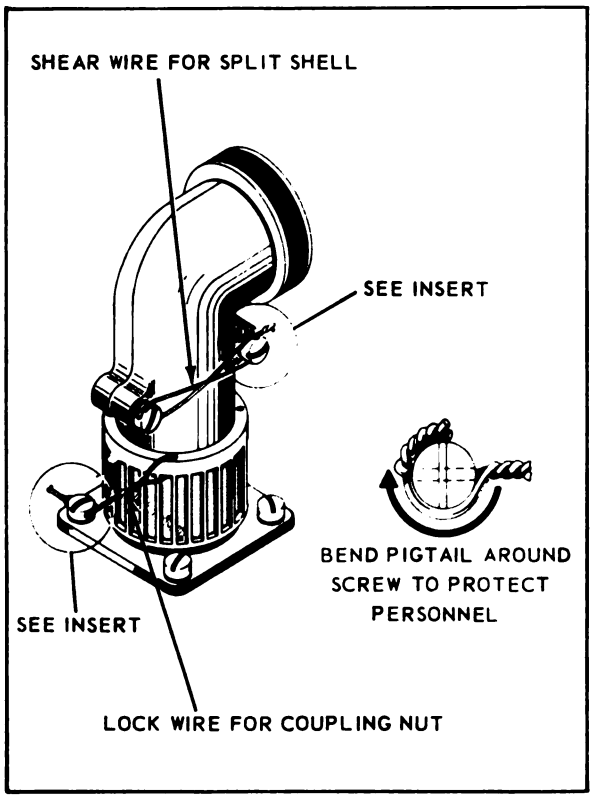


Figure 16–7. Wiring Split Shell Assembly Screws

16–22. SEAL WIRING EMERGENCY DEVICES. See figure 16–8. Use single wire method to secure emergency devices. Make sure that wire is so installed that it can easily be broken when required in an emergency situation.

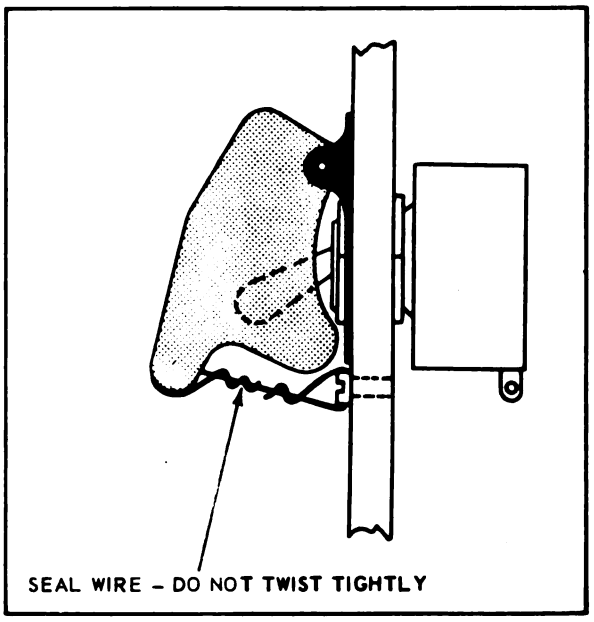


Figure 16–8. Seal Wiring Switch Guard

SECTION XVII

LAMPS USED IN THE AIRCRAFT ELECTRICAL SYSTEM

17–1. INTRODUCTION.

17–2. GENERAL. Lamps are used in aircraft interior general lighting, and in instrument, panel and indicating lights. Lamps used in aircraft exterior lights include those for position, fuselage, wing inspection, landing and taxiing; the last three are of the sealed beam type.

17–3. SCOPE. This section describes and illustrates lamps used in both the interior and exterior circuits of military aircraft.

17–4. REFERENCE SPECIFICATIONS.

W-L-111	Lamp, Incandescent, (Electric, Miniature, Tungsten filament)
MIL-L-6363	Lamps, Incandescent, Aviation Service, General Requirements for
MIL-L-6723	Lights, Aircraft, General Specification for
MIL-L-6730	Lighting Equipment, Exterior, Installation of
MIL-L-18276	Lighting, Aircraft Interior; Installation of

17–5. LAMP TYPES. The lamps most commonly used in aircraft exterior circuits are listed in table 17–1, with their electrical and physical characteristics. The MS drawing dash numbers, listed in the second column, are usually the same as the commercial designation (trade number) of the lamp. Lamps commonly used in interior circuits are listed in table 17–2. Lamp types are illustrated in figures 17–1 and 17–2.

17–6. ABBREVIATIONS. Abbreviations to describe bulb shape, size and finish, and type of base are as follows:

a. Bulb Shape:

G	Globular
GG	Grimes Globular
S	Straight
T	Tubular
PAR	Parabolic Alum. Reflector
R	Reflector

b. Bulb size is indicated in one-eighth inches of greatest diameter. For example T-8 is a tubular lamp, 1 inch diameter.

c. Bulb finish is indicated by letters preceding the MS dash number as follows:

R	Red
SB	Silvered Bowl

If no letter is present, the lamp is clear glass.

d. Base type:

Min. Bay.	Miniature Bayonet
S. C. Bay.	Single Contact Bayonet Candelabra
S. C. Min. Flg.	Single Contact Miniature Flanged
S. C. Mid. Flg.	Single Contact Midget Flanged
Scr. Term.	Screw Terminal
Sub. Mid. Flg.	Sub Midget Flanged

17–7. GENERAL PRECAUTIONS. When installing lamps in the aircraft electrical circuit, observe the following:

a. Replace a burnt-out or damaged lamp with a lamp of the same MS number, or the approved alternate.

Note

The trade number, which is usually the same as the MS dash number, is stamped on the base of each lamp.

b. Make sure the glass bulb of the lamp is clean and free from grease and dirt. To help keep bulbs clean, avoid touching the glass bulb with bare hands if possible.

c. Do not force a lamp into its socket. Check to see if the lamp will fit properly in only one position.

TABLE 17-1

Lamps Used in Aircraft Lighting - Exterior

Part No.	Dash No.	Bulb	Base	Volts	Amps *	Use (Typical)
MS15570	-303	G-6	S.C. Bay.	28	.30	Fuselage Lights
MS25231	-313	T-3-1/4	Min. Bay.	28	.17	Exterior Lights
MS25235	-311	S-11	S.C. Bay.	28	1.29	Fuselage Lights
MS25238	-301	G-5	S.C. Bay.	28	.17	Anchor Light
MS25241	-4553	PAR-46	Scr. Term.	28	250W	Landing Lights
	-4581	PAR-46	Scr. Term.	28	450W	Landing Lights
	-4582	PAR-46	Scr. Term.	28	450W	Helicopter Land/ Hover Lights
MS25242	-4559	PAR-64	Scr. Term.	28	600W	Landing Lights
MS25243	-4502	PAR-36	Scr. Term.	28	50W	Taxiing; Wing Insp.
	-4505	PAR-36	Scr. Term.	28	50W	Position Light
MS25309	-600	GG-10	S.C. Bay.	6.2	26W	Wing Lights
	-1506	GG-10	S.C. Bay.	6.0	21W	Wing Lights
MS35478	-307	S-8	S.C. Bay.	28	.67	Tail Position Light
	-1680	S-8	S.C. Bay.	6	4.10	Tail Position Light
AN3120	-1047	RP-11	S.C. Bay.	26	2.7	Signalling Light
------	-1959	T-4 (Quartz)	Tab	28	150W	Position Light

*Amps unless otherwise noted: W - Watts

TABLE 17-2

Lamps Used in Aircraft Lighting - Interior

Part No.	Dash No.	Bulb	Base	Volts	Amps	Use (Typical)
MS24515	-682	T-1	Sub. Mid. Flg.	5	.06	Instrument Panel
	-685	T-1	Sub. Mid. Flg.	5	.06	Instrument Panel
	-718	T-1	Sub. Mid. Flg.	5	.115	Instrument Panel
MS25231	-313	T-3-1/4	Min. Bay.	28	.17	Indicating Light
	-R313	T-3-1/4	Min. Bay.	28	.17	Indicating Light
	-316	T-3-1/4	Min. Bay.	6	.70	Instrument Panel
MS25235	-311	S-11	S.C. Bay.	28	1.29	Work Table Light
	-R311	S-11	S.C. Bay.	28	1.29	Interior Lighting
	-SB311	S-11	S.C. Bay.	28	1.29	Cabin Dome Light
MS25237	-327	T-1-3/4	S.C. Mid. Flg.	28	.04)	Indicating Light;
	-328	T-1-3/4	S.C. Mid. Flg.	6	.02)	Instrument Panel
MS35478	-307	S-8	S.C. Bay.	28	.67	Cabin Dome Light
	-R307	S-8	S.C. Bay.	28	.67	Interior Lighting
	-SB307	S-8	S.C. Bay.	28	.67	Interior Lighting
MS25239	-4501	PAR-36	Scr. Term.	26	5.3	Flashing Signal

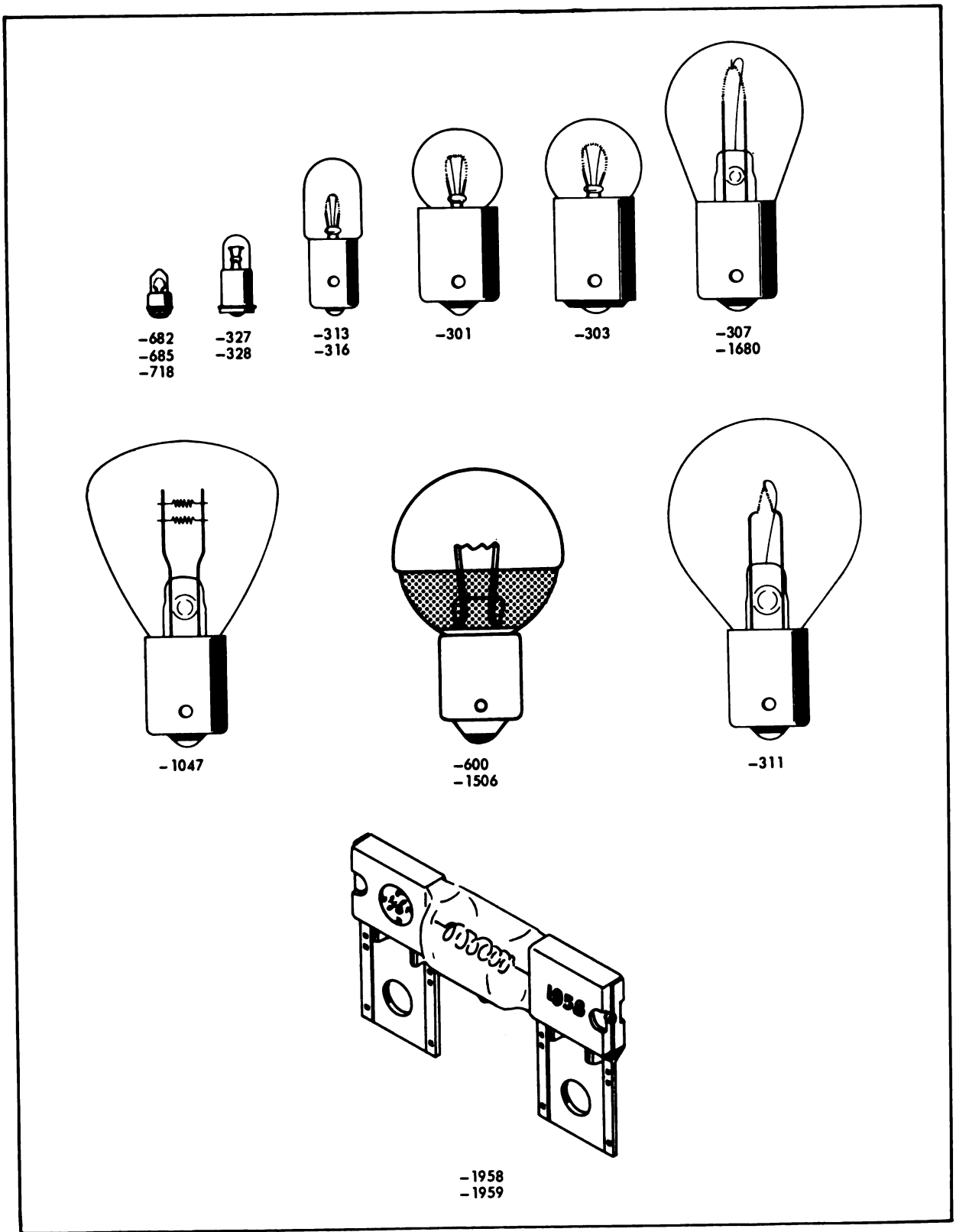


Figure 17-1. Lamps Used in Aircraft Electrical systems

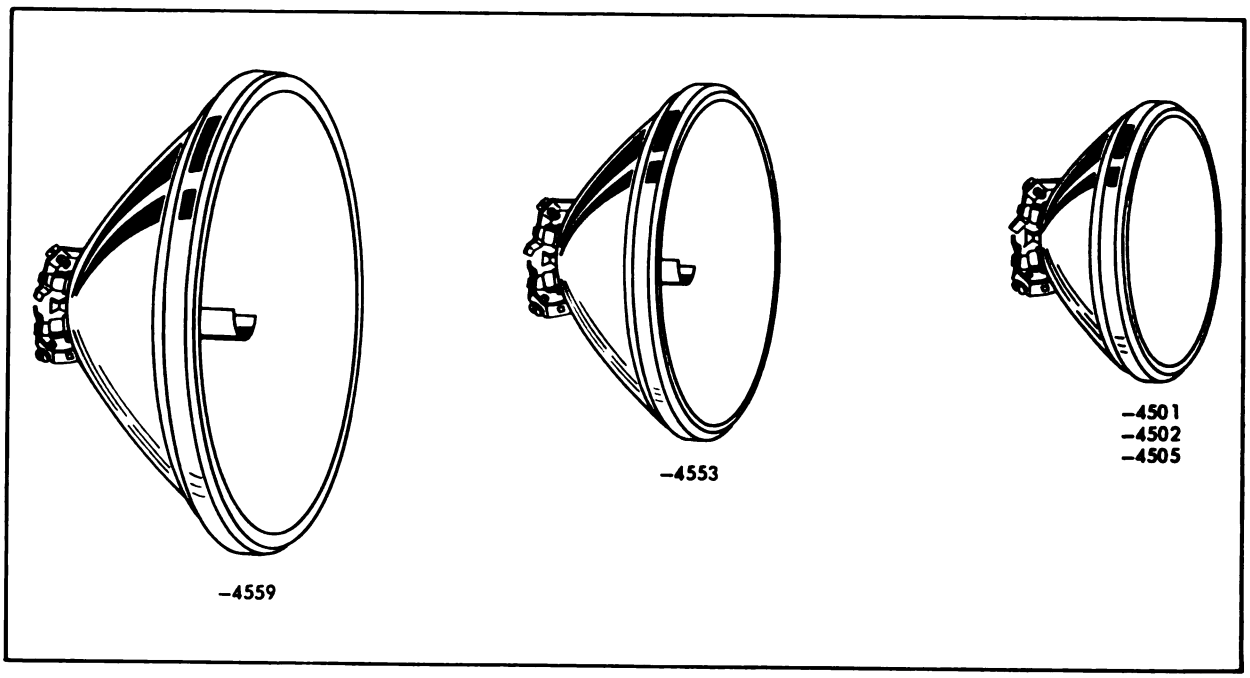


Figure 17–2. Aircraft Lamps – Sealed Beam Type

SECTION XVIII

FUSES USED IN THE AIRCRAFT ELECTRICAL SYSTEM

18–1. INTRODUCTION.

18–2. GENERAL. Fuses are current-limiting devices used in the aircraft electrical system to afford electrical protection against short circuits and system faults.

18–3. SCOPE. This section describes and illustrates types of fuses commonly used in aircraft electrical systems. Procedures for installing fuses and other protective devices are given in Section XIII.

18–4. REFERENCE SPECIFICATIONS AND DRAWINGS.

MIL-F-5372	Fuse, Enclosed Link, Aircraft, 400-Cycle AC
MIL-F-5373	Fuseholders, Block Type, Aircraft
MIL-F-15160	Fuses; Instrument, Power and Telephone
MIL-F-19207	Fuseholders, Extractor Post Type, Blown Fuse Indicating and Nonindicating
MS18091	Fuseholder-Cartridge, Extractor Post Style FHN46G
MS18092	Fuseholder-Cartridge, Extractor Post Style FHN47G
MS24000	Fuse Holder, Block Type, 1-, 2-, and 3-Pole, 1- to 30-Ampere, Aircraft
MS24001	Fuse Holder, Block Type, 1-, 2-, and 3-Pole, 35 to 60-Ampere, Aircraft
MS25474	Fuseholder, Cartridge, Extractor Post, Style FHN28G
MS26572	Fuseholder-Cartridge, Extractor Post

18–5. DESCRIPTION.

18–6. FUSES. See Figure 18–1. Fuses used in aircraft are of two types: the cartridge type, installed in the electrical system in an extractor post style fuseholder or in fuse clips, and the enclosed link type (current limiter) installed in a block type fuseholder. Fuses commonly used in aircraft electrical systems are listed in table 18–1.by detailed Military Specifications and Military Standard Drawings.

18–7. FUSEHOLDERS. See Figure 18–2. Extractor post fuseholders in accordance with Military Standard Drawings MS18091, MS18092, MS25474 and MS26572 are used in conjunction with cartridge type fuses. Block type fuseholders in accordance with Military Standard Drawings MS24000 and MS24001 are used with enclosed link fuses.

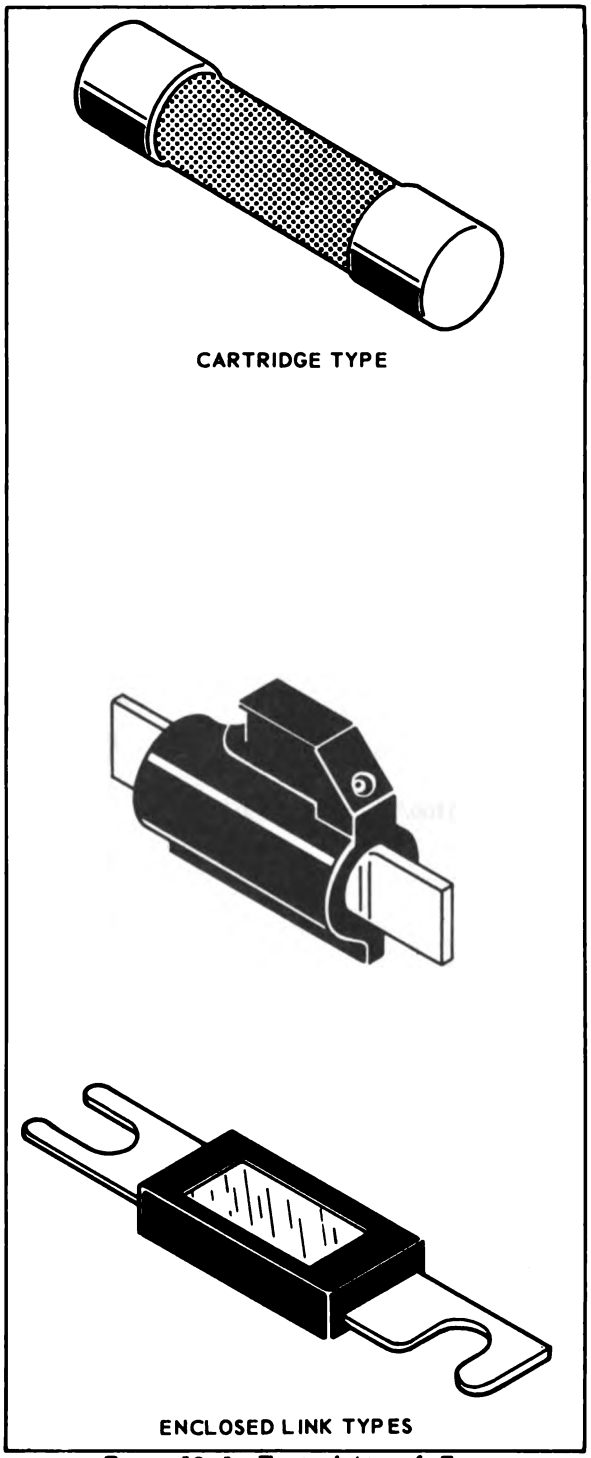


Figure 18–1. Typical Aircraft Fuses

TABLE 18-1

Fuses Used in Aircraft Electrical System

1. Cartridge Type

Number	Style	*Characteristic	Max. Volts	Amperes	Replaces MS Number: Char. A	Char. B
MIL-F-15160/02	FO2	A,B	250	1/100	90078- 1-1	90078-16-1
		A,B		1/32	- 2-1	-17-1
		A,B		1/16	- 3-1	-18-1
		A,B		1/8	- 4-1	-19-1
		A,B		1/4	- 5-1	-20-1
		A,B		3/8	- 6-1	-21-1
		A,B		1/2	- 7-1	-22-1
		A,B		3/4	- 8-1	-23-1
		A,B		1	- 9-1	-24-1
		A		1- 1/2	-10-1	-
		A		2	-11-1	-
		A		3	-12-1	-
		A		4	-13-1	-
		A		5	-14-1	-
		A		6	-15-1	-
		B	125	1- 1/2	-	90078-25-1
		B		2	-	-26-1
		B		3	-	-27-1
		A,B	32	10	-	-
		A,B		15	-	-
		A,B		20	-	-
		B	32	5	-	-
		B		8	-	-
MIL-F-15160/03	FO3	A,B	250	1	90079- 1-1	90079-20-1
		A		3	- 2-1	-
		A		5	- 3-1	-
		A		8	- 4-1	-
		A		10	- 5-1	-
		A		12	- 6-1	-
		A		15	- 7-1	-
		B	250	1/100	-	90079-10-1
		B		1/32	-	-11-1
		B		1/16	-	-12-1
		B		1/8	-	-13-1
		B		15/100	-	-14-1
		B		3/16	-	-15-1
		B		1/4	-	-16-1
		B		3/8	-	-17-1
		B		1/2	-	-18-1
		B		3/4	-	-19-1
		A	125	20	90079- 8-1	
		A		30	- 9-1	
		B	125	3		
		B	32	5		
		B		8		
		B		10		
		B		12		

TABLE 18-1 (CONT)

Fuses Used in Aircraft Electrical System

Number	Style	*Character-istics	Max. Volts	Amperes	Replaces MS Number: Char. A	Char. B
MIL-F-15160/03	FO3	B	32	15		
		B		20		
		B		30		
MIL-F-15160/05	FO5	A,B	32	10	90081-1	90081-8
		A,B		15	-2	-9
		A,B		20	-3	-10
		A,B		25	-4	-11
		A,B		30	-5	-12
MIL-F-15160/06	FO6	A	250	1	90082-1	
		A		2	-2	
		A		3	-3	
		A		5	-4	
		A		10	-5	
		A		15	-6	
MIL-F-15160/07	FO7	A	250	1		
		A		2		
		A		3		
		B	125	1		
		B		2		
		B		3		
		A,B	32	5	90083-1	90083-10
		A,B		10	-2	-11
		A,B		15	-3	-12
		A,B		20	-4	-13
		A,B		30	-5	-14

*A Normal (normal interrupting capacity); for general circuit protection
B Time Lag; for circuits containing motors, and circuits where provision must be made for momentary suges.

2. Enclosed Link Type

MS Part Number	Voltage Rating	Current Rating	Type
MS24124- 5	115/200 vac	5 amps	A
-10		10 amps	A
-20		20 amps	A
-30		30 amps	A
-40		40 amps	A
-50		50 amps	A
-60		60 amps	A
MS24125- 5	115/200 vac	5 amps	B
-10		10 amps	B
-20		20 amps	B
-30		30 amps	B
-40		40 amps	B
-50		50 amps	B
-60		60 amps	B

18–8. IDENTIFICATION. Cartridge type fuses are marked with the current and voltage ratings, style designation and characteristic letter as listed in table 18–1. Enclosed link fuses are identified with the MS part number and the amperage rating.

18–9. GENERAL PRECAUTIONS. When replacing fuses in the aircraft electrical system, observe the following precautions:

a. Do not use tools to remove or insert fuses.

b. Make sure that the new fuse has the same electrical features as the fuse being replaced.

CAUTION

Cartridge fuses marked FO2 and FO3 are 1-1/4 inches long and 1/4 inch diameter; fuses marked FO5 and FO6 are 1-1/4 inches long and 9/32 inch diameter. Do not interchange the two sizes.

c. Make sure that the plating on all metal parts is clean and intact.

d. Make sure that the wire inside the replacement fuse exhibits continuity.

e. Make sure that the replacement fuse has no cracks or breaks.

f. Do not force a fuse into a holder that does not readily accept it; check that a fuse of the correct size is being used.

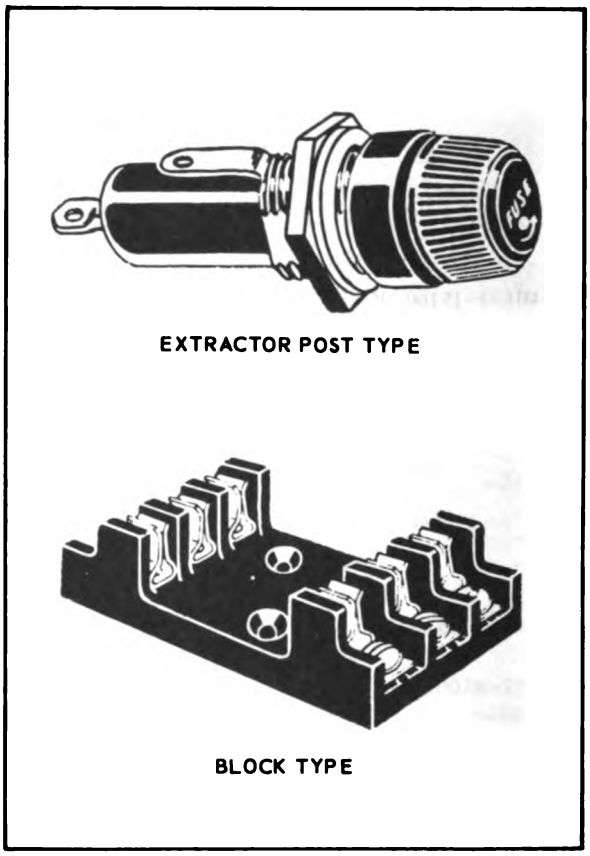


Figure 18–2. Typical Fuse Holders

SECTION XIX

EMERGENCY REPAIRS

19–1. INTRODUCTION.

19–2. GENERAL. It is sometimes necessary to make emergency repairs to the aircraft electrical wiring system at advanced fields, where a minimum of tools and equipment are available.

19–3. SCOPE. This section describes and illustrates some recommended procedures for emergency repairs to broken or damaged copper wires, shielded and coaxial cable, electric connectors; and for replacing terminal board covers.

CAUTION

All repairs described in this section are temporary, for emergency use only. Replace all temporary repairs as soon as possible with permanent repairs.

19–4. REPAIRING BROKEN OR DAMAGED WIRES.

19–5. METHODS OF REPAIRING WIRE. Repair of broken wires is accomplished by means of crimped permanent splices, by the use of a terminal lug from which the tongue has been cut off, or by soldering together the broken strands, and applying potting compound. Breaks in large wire (AN size No. 12 and larger) are repaired by means of terminal lugs bolted together.

19–6. SPLICING BROKEN WIRES WITH PERMANENT SPLICE. See figure 19–1. When splicing wires by means of permanent splices observe the following procedures.

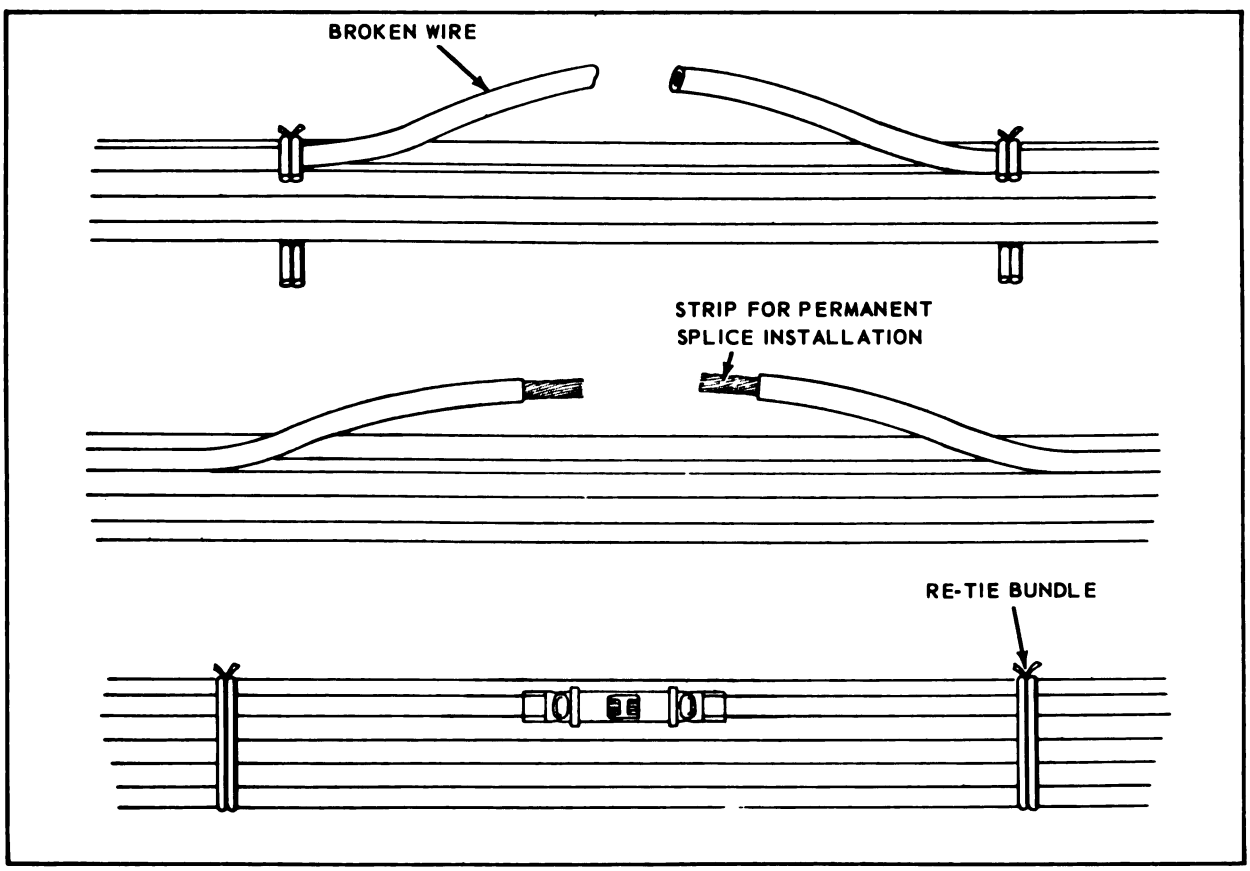


Figure 19–1. Permanent Splice Repair of Wire

Note

Make sure that only aluminum splices are used when splicing aluminum wires.

a. Cut ties and work the broken wire to the outside of the bundle.

b. Pull sufficient slack from the wire run toward the break so that there will be no strain on the splice.

c. Trim the wire as close to the break as possible so that all strands will be of equal length.

d. Clean the wire for a distance of at least one inch from the break with Stoddard's solvent. This will insure the removal of foreign particles and debris to provide a good insulating surface.

e. Slide a piece of shrinkable tubing slightly larger in diameter than the OD of the splice being used over one end of the severed wire. (See table 11–11) If shrinkable tubing is not available a piece of flexible transparent tubing can be substituted.

f. Install the splice as described, in section V, paragraph 5–63, and re-tie spliced wire into bundle.

19–7. SPLICING WITH TERMINAL LUG BARREL. When a permanent splice is not available the barrel of a terminal lug can be used.

a. Select a terminal lug with a barrel large enough to accommodate both wires.

b. Cut off the terminal lug tongue.

c. Prepare the wires as described in 19–6.

d. Insert the wires from opposite ends of the barrel so that each wire protrudes thru the barrel 1/32 inch.

e. Crimp the barrel in the center following the procedures of section V. (See figure 19–2.)

f. If shrinkable tubing is used, procedure as described in section XI, paragraph 11–22 applies. If flexible transparent tubing is used slide the sleeving down over the connection so that it extends about 1/2 inch past each end of the crimped barrel and then tie it with nylon cord at each end.

19–8. SPLICING WITH SOLDER AND POTTING COMPOUND. When neither a permanent splice nor a terminal lug is available repair a broken wire as follows: (See figure 19–3.)

a. Install a piece of plastic sleeving about 3 inches long, and of the proper diameter to fit loosely over the insulation, on one piece of broken wire.

b. Strip approximately 1-1/2 inches from each broken end of wire.

c. Lay the stripped ends side by side and twist one wire around the other with approximately four turns.

d. Twist free end of second wire around first wire with approximately four turns. Solder wire turns together, using 60/40 tin-lead rosin core solder.

e. When solder is cool, draw sleeve over soldered wires and tie at one end. If potting compound is available, fill sleeve with material prepared in accordance with section X, and tie securely.

f. Allow potting compound to set without touching for 4 hours. Full cure and electrical characteristics are achieved in 24 hours.

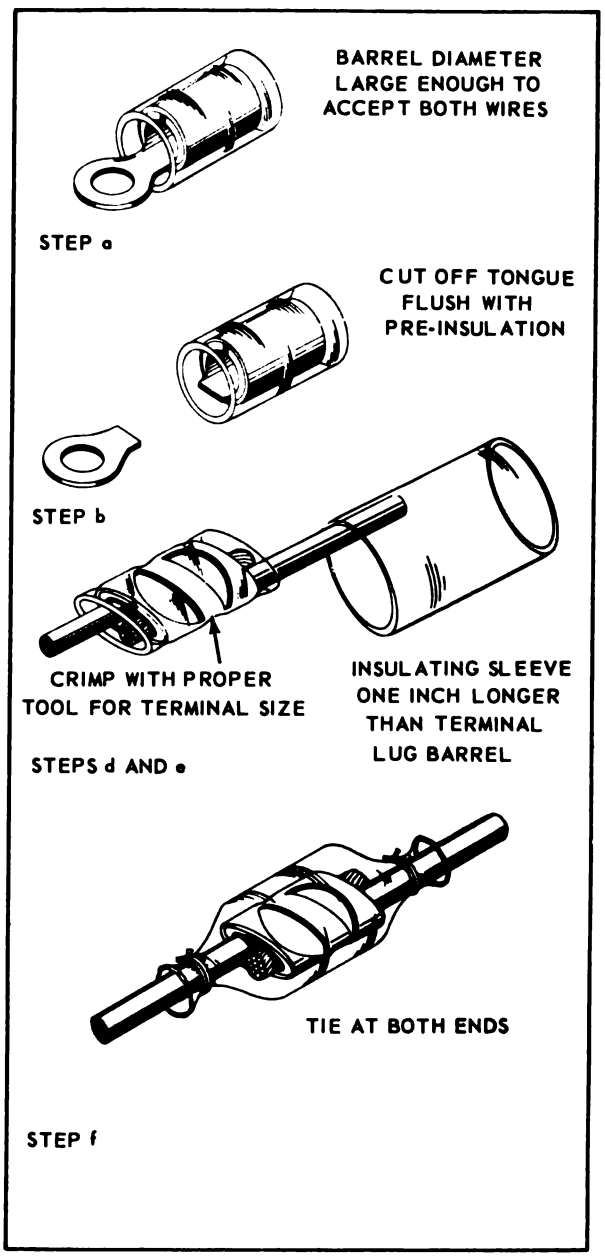


Figure 19–2. Terminal Lug Barrel Repair of Wire

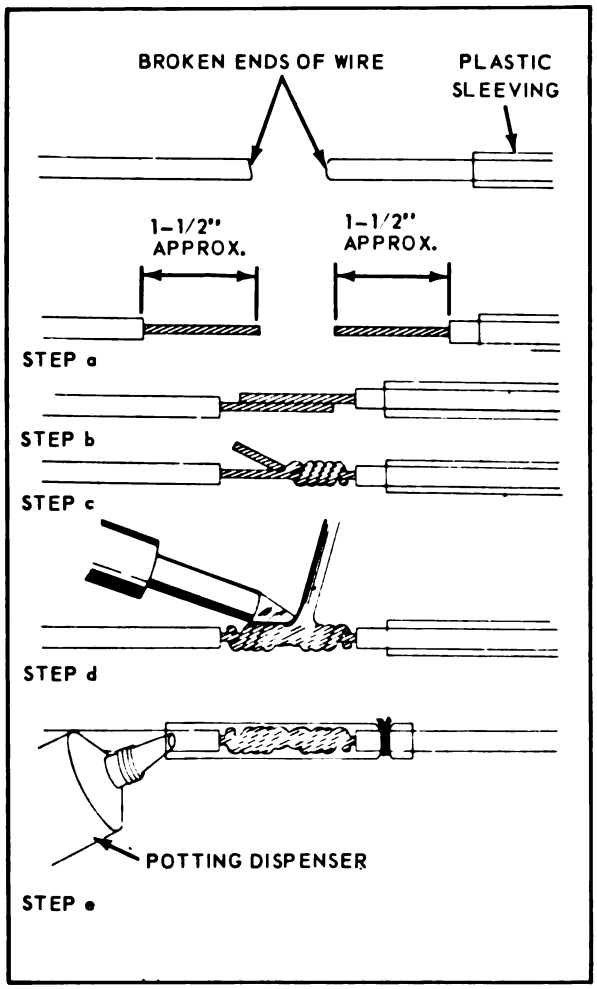


Figure 19–3. Repairing Broken Wire by Soldering and Potting

19–9. SPLICING LARGE WIRE WITH TERMINAL LUGS. Trim the broken ends of the wire, and install an insulating sleeve over one end of the wire. Strip wire, and crimp an insulated terminal lug of the proper size to each wire end, following procedures described in section V. Bolt the terminal lugs together as shown in figure 19–4. Slide the insulating sleeve over the connection and tie securely to the wire at both ends.

19–10. REPAIRING DAMAGED WIRE INSULATION. If the wire insulation is damaged but the wire itself is not damaged, repair the insulation in either of the following ways:

a. Dip the damaged portion of the wire insulation into a container of potting compound. Instructions for mixing potting compound are given in section X. Allow potting compound to dry in air (70°–75°F) for 4 hours before touching. Full cure and electrical characteristics are achieved in 24 hours.

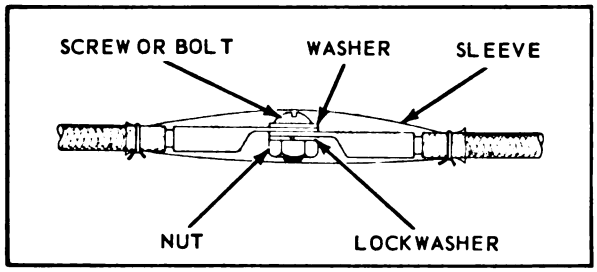


Figure 19–4. Bolted Terminal Lug Repair of Large Wire

b. If potting compound is not available, repair damaged wire insulation by using a transparent sleeve of flexible tubing 1-1/2 times the outside diameter of the wire and 2 inches longer than the damaged portion of the insulation. This sleeving is split lengthwise and wrapped 1-1/2 times around the wire at the damaged section. Tie with nylon braid at each end and at one inch intervals over the entire length. See figure 19–5.

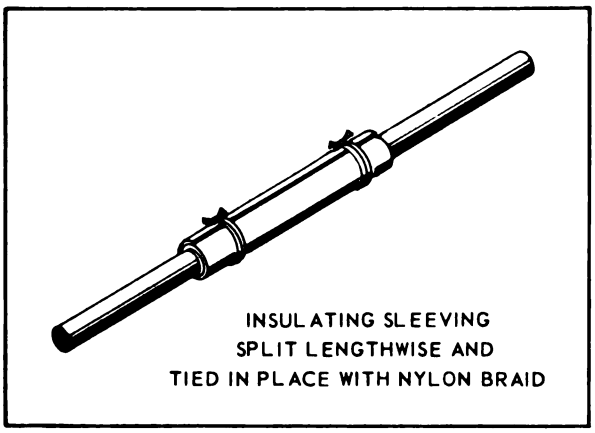


Figure 19–5. Insulation Repair With Sleeving

19–11. REPAIRING SHIELDED CABLE. When shielded cable is severed it can be repaired in the following manner: (See figure 19–6)

a. Select a grounding sheath according to instructions in section II, paragraph 2–59, steps a and b.

b. Prepare the severed ends of the cable for application of a grounding sheath connector as described in section II, paragraph 2–59, steps c and d.

c. Slide two insulating sleeves, either shrinkable or flexible transparent tubing, the inner one just large enough to pass over the grounding sheath connector, and the outer one large enough to accommodate the inner insulating sleeve and the grounding lead. The inner insulating sleeve should be just long enough to completely cover the permanent splice. The outer sleeve must be long enough to extend beyond the two grounding sheath connectors as shown in figure 19–6.

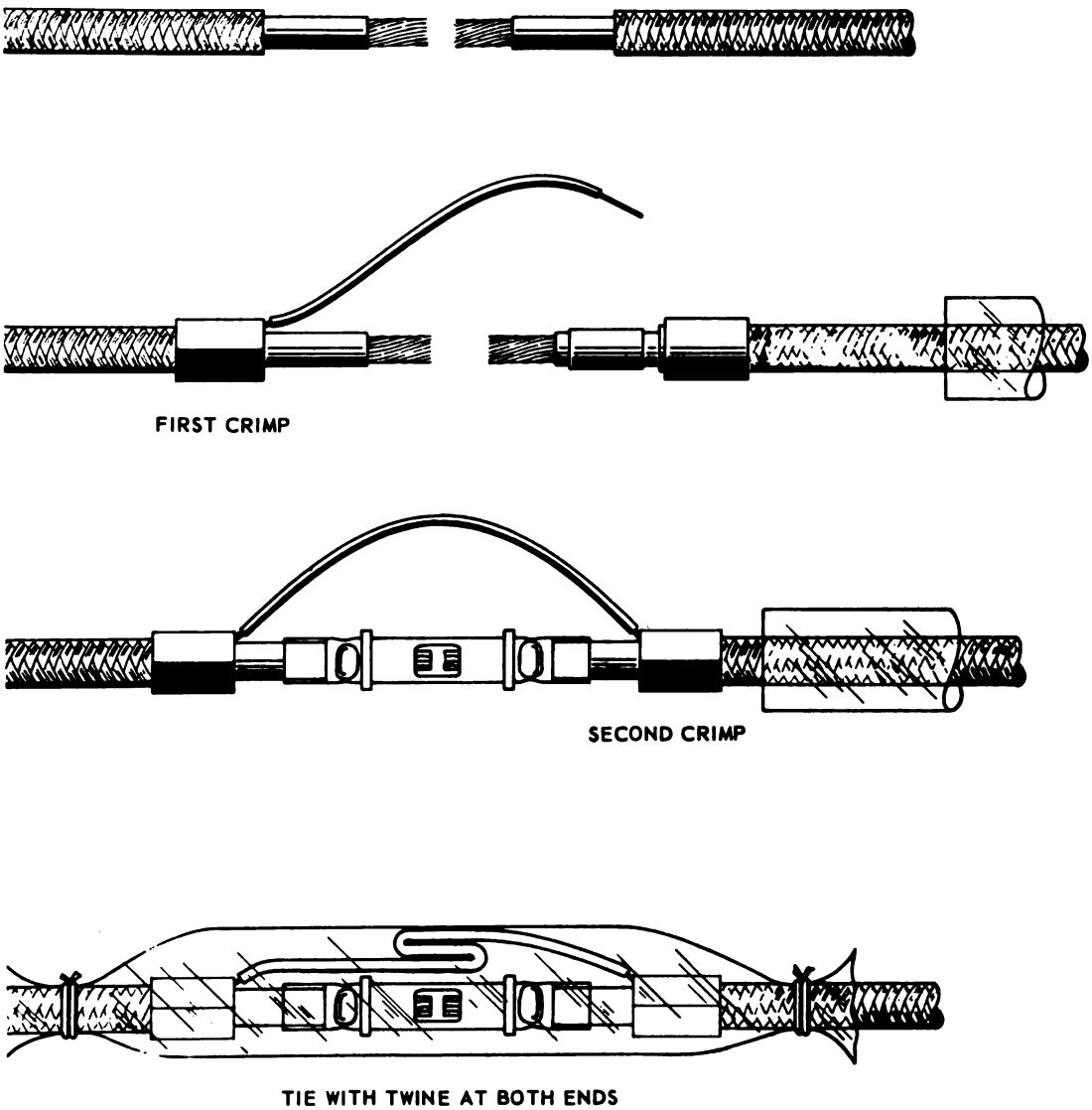


Figure 19–6. Repair of Shielded Wire

d. Attach a grounding sheath connector to one end of the severed wire per section II, paragraph 2–59, steps e through j. The grounding wire should be long enough to span the repair.

e. Install a grounding sheath connector on the other side of the break. Do not crimp this yet.

f. Use a permanent splice to join the severed inner conductor, or use the barrel of a terminal lug when a permanent splice is not available. See 19–6 and 19–7.

g. Slide inner insulating sleeve into position as shown in figure 19–6. If shrinkable tubing is used apply heat as described in section XI, paragraph 11–22.

h. Push the free end of the grounding wire from step c, above, into the uncrimped grounding sheath connector. Crimp securely.

i. Slide outer insulating sleeve into place. If shrinkable tubing is used proceed as in step g above. If flexible tubing is used tie both ends with nylon braid as shown.

19–12. An alternate method of repairing shielded cable is to be used if grounding sheath connector as described in 19–11 is not available. The alternate method shown in figure 19–7 is as follows:

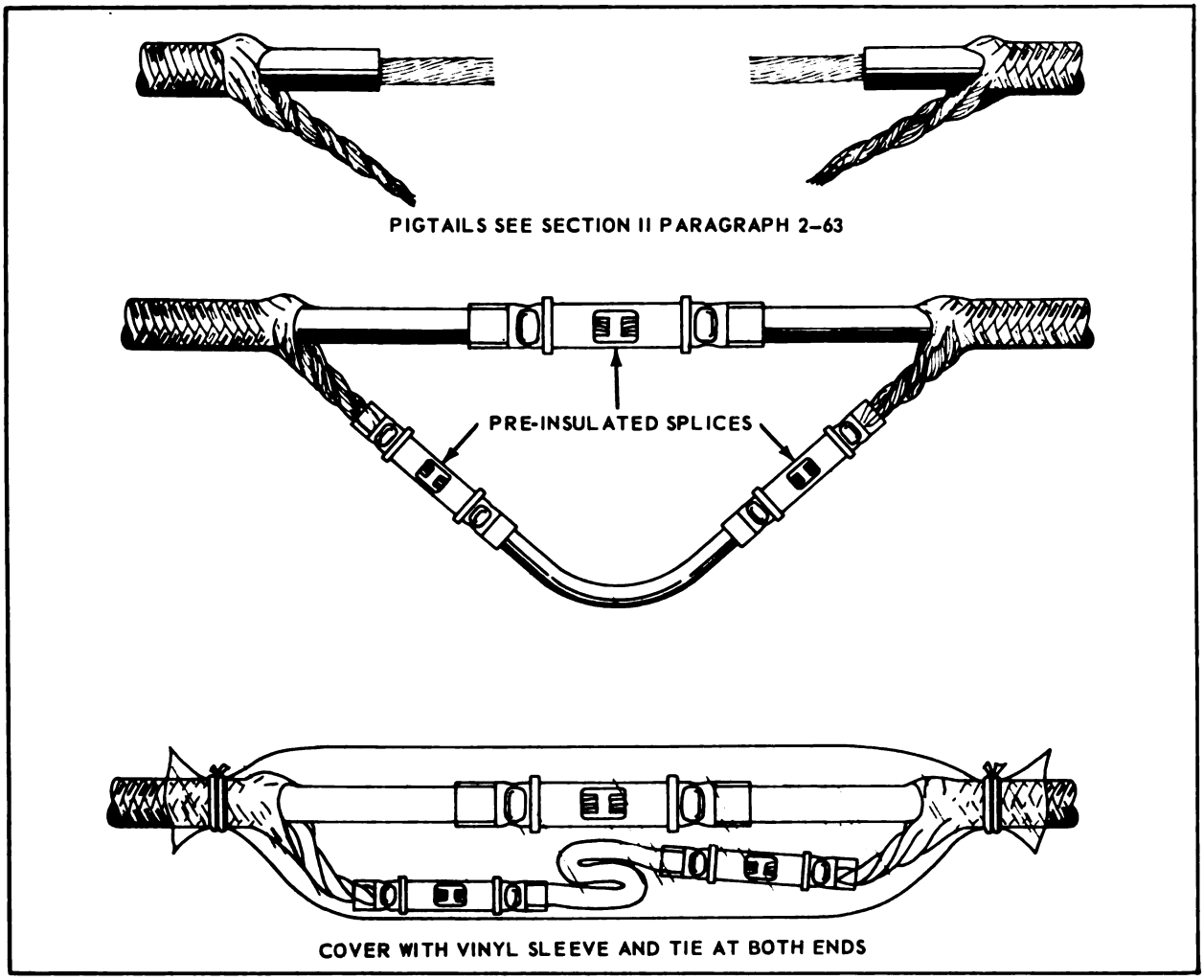


Figure 19–7. Alternate Repair of Shielded Wire

a. Prepare the severed ends of the cable for pigtail method of shield termination as described in section II, paragraph 2–63, steps a through d.

b. Use pre-insulated splice connector to join inner conductors as described in section V, paragraph 5–63.

c. Use two splice connectors to add short length of insulated wire as extension to complete shield connection.

19–13. REPAIRING DAMAGED SHIELDING. When the shielding braid of shielded cable has been damaged, cut the cable sharp and square, and repair as described in 19–11 or 19–12.

CAUTION

Do not attempt to repair damaged shielding braid by covering with tape, as it is not possible to seal off severed ends, and these may puncture the wire insulation.

19–14. REPAIRING COAXIAL CABLE. Do not attempt to patch up broken or damaged coaxial cable. If possible replace the entire cable. If this is not possible, install a matching plug and jack of the proper size and type at the broken or damaged part, using the procedures described in section IV.

CAUTION

As every extra connection in a coaxial cable means a loss in efficiency, replace repaired coaxial cables at the earliest possible time.

19–15. REPAIRING DAMAGED MS CONNECTORS.

19–16. REPAIRING UNPOTTED CONNECTORS. Defective MS connectors which have broken pins can be temporarily reqpaired in the following manner:

a. Where it is possible to get at both halves of the connector one of the spare wires provided may be used by splicing the wire from the damaged or broken pin to the spare wire following the procedures of Section V, paragraphs 5–63 through 5–69. This procedure must be followed for the wire leading to both halves of the connector. The unit must then be marked that this repair has been done. Replace both altered connectors at the next major overhaul of the aircraft.

19–17. REPAIRING POTTED CONNECTOR. Potted connectors are equipped with spare wires on all spare pins. If a pin becomes defective the repair is made by cutting the wire leading to the defective pin and using a permanent splice (as previously described) to join the wire to a spare wire. The mating connector must also be so modified.

CAUTION

Tag both connector halves with complete information on the modification. Replace both connector halves at the earliest opportunity.

If a spare wire is not available, it is possible to replace pins in potted *resilient* connectors which do not have metallic back shells. The following procedure should be carefully followed:

a. Cut away the potting compound (sealant) with a thin knife blade or scalpel. Use long nose pliers to pull the sealant while cutting. Be careful not to cut into wire insulation.

b. Carefully scrape away sealant from defective pin.

c. Use a small (pencil) soldering iron or a soldering gun to unsolder the wire lead from pin.

d. Use long nose pliers to pull pin out of resilient insert.

e. Solder wire to new pin and push pin into insert from rear.

f. Pour new potting compound into area of repair and air cure at room temperature for 24 hours. The new compound will seal satisfactorily to the old compound remaining in connector.

19–18. Occasionally a wire will fail inside the potted area of a connector. When the connector has a back shell, slide a thin knife blade around the outside edge of the sealant and unscrew the shell. This may take considerable force, depending on how tightly the sealant adheres to the shell. Follow the same steps as described above to reach the soldered conjunction. Do not remove the pin, but solder a new wire to the contact and repot the connector.

19–19. REPLACING TERMINAL BOARD COVERS. When a terminal board cover is lost or damaged so as to be unuseable, cover the board temporarily with a piece of large vinyl tubing, split lengthwise, and tied securely around the terminal board. This procedure is described in section XIII, paragraph 13–52.

CATUION

All repairs described in this section are temporary, for emergency use only. Replace all temporary repairs as soon as possible with permanent repairs.

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